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A framework for the evaluation of air pollution caused by motor vehicles.

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A Framework for the Evaluation of Air Pollution Caused by Motor Vehicles

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Abstract

This research investigated the problem of air pollution caused by vehicles in the city of Tripoli, Libya. This also included the identification of the socioeconomic and institutional factors which have contributed to the increased severity of the air pollution problem. The issues addressed included legal, institutional and technical aspects. A descriptive method was applied in which a case study approach was adopted. Primary data were collected through personal interviews with responsible people in relevant institutions, including EGA, GTL and ATD, complemented by questionnaires and direct observations. The data collected from the interviews and questionnaires were analysed using Excel and SPSS software.

Owing to the lack of data on vehicular emissions in the study area, an inventory of the annual vehicular emissions in the city was made through the application of COPERT.4 software which is widely used for calculating vehicular emissions. This inventory covered the period from 2005 to 2010. Laboratory Mobile was also used to measure the concentration of vehicular emissions in the city centre of Tripoli, and compared with the vehicular concentrations in Sheffield, UK, for the same period.

A framework was developed and validated to evaluate the air pollution caused by vehicles in Tripoli. The findings from the research showed that there has been a dramatic increase in the quantity of vehicle emissions in the city, highlighting the extent of the problem. Some influencing factors which have made a significant contribution to the occurrence and increased severity of traffic air pollution in Tripoli include: the increase in the vehicle fleet, the quality and quantity of the fuel consumed, insufficient public transportation, a shortage of public awareness, and deficiencies in the relevant legislation. Obstacles facing the responsible institutions include a lack of capable and qualified staff, and a shortage of necessary equipment for monitoring and addressing traffic problems and pollution.

It is concluded that Tripoli has been subjected to air pollution caused by vehicles, which needs to be addressed through the incorporation of a comprehensive strategy and implementation of the developed framework. Additionally, economic, legal, institutional and technical recommendations are presented for the management of air pollution caused by vehicles in the city of Tripoli, Libya.

DEDICATION

I dedicate my dissertation to my family, relatives and all my friends.

A special dedication goes to my father who was always praying to Allah in order to provide me the needed determination and strength to obtain my PhD. A great dedication to my wife, my children: Mohamed, Omnia, Ayat and Abdulmalek, who always provided me with an appropriate environment and helped me to overcome a lot of difficulties that I faced during the period of my study.

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I owe great appreciation and gratitude to every member of my family, including my father, my wife and my children, who sacrificed much of their time and have given up a lot of their rights in order to encourage me to complete my thesis.

Finally, I wish express my thanks and my appreciation to all those who were always waiting with me for this happy moment.

LIST OF ABBREVIATIONS

ATD: Association of Taxi drivers.

BC: Brega Company for fuel marking in Tripoli.

CO: Carbon monoxide

CO_2: Carbon Dioxide

COPERT: A software tool to calculate air pollutant and greenhouse gas emissions from road transport

DPSIR: (Driving forces, Pressures, States, Impacts, and Responses) is a general framework for organising information about the state of the environment.

DVR: Department of vehicle registration in Tripoli

EGA: Environment General Authority

GTL: General department of traffic and licensing in city of Tripoli.

HBEFA: The Handbook Emission Factors for Road Transport

HC: Hydrocarbon

I / M: Inspection and maintenance of vehicle

IPCC: Intergovernmental panel on climate change.

LAS: League of Arabs states

mg/m^3: Milligram of gaseous pollutant per cubic meter of ambient air.

mt: Metric Tonne.

N_2O: Nitrous Oxide

NAI: National authority for information.

NCM: National centre of meteorology.

NMVOC: Non-methane volatile organic compounds

NO: Nitrogen monoxide

N02: Nitrogen dioxide

NH3: Ammonia.

NOx: Nitrogen Oxides

PM: Particulate matters

PM exhaust: Particulate matter emitted from vehicle exhaust

PM2.5: Particulate Mather of 2.5 micrometres.

PM10: Particulate Mather of 10 micrometres.

RVP: Reid vapours pressure.

S02: Sulphur dioxide

UNEP: United nations environment programme

US - DOT: United State - Department of Transportation

VOC: Volatile organic compounds

VOCs: Volatile organic compounds

WB: World Bank

TABLE OF CONTENTS

CHAPTER ONE: THESIS INTRODUCTION

CHAPTER TWO: AIR POLLUTION CAUSED BY VEHICLES - OVERVIEW

CHAPTER THREE: RESEARCH METHODOLOGY

CHAPTER FOUR: FIELD WORK OBSERVATIONS

CHAPTER FIVE: THE INVENTORY OF VEHICULAR EMISSIONS IN TRIPOLI - LIBYA

CHAPTER SIX: ANALYSIS OF THE QUESTIONNAIRE

CHAPTER SEVEN: ANALYSIS OF THE INTERVIEWS

CHAPTER EIGHT: DISCUSSION OF THE FINDINGS

CHAPTER NINE: UTILISATION OF THE FRAMEWORK TO TEST VARIOUS SCENARIOS FOR EVALUATION OF AIR POLLUTION CAUSED BY MOTOR VEHICLES IN TRIPOLI- LIBYA

CHAPTER TEN: CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

TABLES

List of FIGURES

List of PHOTOGRAPHS

List of APPENDICES

Chapter One

Thesis Introduction

1.1. Introduction

This chapter presents an overview of the research problem and the reasons why the researcher chose this problem for this research. Then it presents the aims and objectives of the research, the research questions, the research scope as well as the significance of the research, and the chapter concludes with an explanation of the organization of the thesis.

1.2. The research problem

Air pollution is defined as “the introduction by man, directly or indirectly, of substances into the air, which results in harmful effects of such nature as to endanger human health, harm living resources and ecosystems, cause material damage, interfere with amenities and other legitimate uses of the environment” (UNEP, 1997). The sources of air pollution are human activities that could produce air pollutants in quantities and concentrations that are capable of creating an imbalance in the natural components of the atmosphere and thus damaging and polluting the air quality. The major sources of human activities that cause air pollution in cities are motor traffic, industry, power plants, and domestic fuel (Mayer, 1999). The road transport sector brings an economic advantage in meeting the daily requirements of citizens for travel and shopping, visits, and access to workplaces and education locations. Moreover, it is a resource of employment for many people, providing jobs in the field of vehicle trade, maintenance, and driving for the transport of passengers and goods. There is also revenue from taxes on imported vehicles. Nevertheless, the studies and environmental research on air pollution confirm that motor vehicles, through consuming fuel in vehicle engines, emit a large amount of substances and gases (Briggs et al., 1997). Land transport is a significant source of air pollution globally. Motor vehicle emissions, including nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), and sulphur dioxide (SO_2) as well as volatile organic compounds (VOC) and ozone, are primary pollutants. In addition, some secondary emissions may occur as a result of interaction between the primary pollutants and certain other elements (Ting and Shaodong, 2009; Baldauf et al., 2010; Kurtulus, 2012).

The air pollutants emitted from land transport in cities, particularly in developing countries, have been considered to be a main source of air pollution in the cities, causing great concern for the responsible institutions and environmental researchers (Soumak et al., 2012). The major human source of air pollution in cities is the motor vehicle. Compared with the other sources of air pollution in the big cities, land transport contributes 70% of total emissions of CO, 50% of HC, 30-40% of NO_x, 30% of PM, and 10% of SO_2 (Goyal et al., 2006). These vehicular emissions can reach people through breathing, touch, and the food chain. Motor vehicles' pollution has serious effects on health, including cancer, respiratory-system illness, genetic mutation, blood toxicity, and more (Briggs et al., 1997; Baldauf et al., 2009). There are also environmental effects including climate change, damage to ecosystems and landscape, as well as economic effects as a result of the cost of damage by air pollution caused by motor vehicles (Slezakova et al., 2012). These costs include the funds needed to treat the risks to health and the environmental ecosystem, as well as the damage to materials and historic buildings and also losses in terms of crop production (Faiz et al., 1996). There have been notable cases of urban air pollution caused by pollutants emitted by motor vehicles, such as in London's Great Smog of 1952, when the streets and roads were covered with black smoke and 4,000 people were killed as a result of this within 4 days. Another 8,000 people died due to its effects in the following weeks and months (Briggs et al. 1997).

The extent of damage to health and the environment caused by vehicular pollutants is directly proportional to the increase in land transport and fuel consumption, particularly in cities with a high density of population, which experience a high density of traffic on the road network. Some cities could suffer more than others because of economic conditions that do not enable them to manage and address the problem and establish an air-quality monitoring system for the control of motor vehicle emissions (Faiz, 1990). The affecting factors include an increase in the numbers of private cars, the time and duration of exposure (including the duration of staying inside a vehicle), physical activity levels, and age and health conditions (U.S. DOT, 1992; Lawrence and Gary, 1994; Cervero, 1988), as well as the types of technologies used in fleet vehicles, fuel consumption, weather conditions, and topographical conditions (Gorham, 2002).

The air pollution problem already receives attention from many specialists and researchers in many developed countries and in some developing countries where research has shown the seriousness of this problem and the main affecting factors that contribute to occurrence and increase. Such studies have provided alternative options for addressing this problem, taking into account the economic conditions and social dimensions, legal and functional possibilities, and human resources that vary from one city to another and from one country to another. Many countries, both developing and developed, have created strategies for addressing traffic air pollution. These options include air-quality standards, the establishment of a monitoring system to control air quality, and the approval of educational and cultural programmes to increase public awareness of the importance of air quality, in addition to the awareness of decision-makers. Many Arab countries have approved limited funds for monitoring and control, with the aim of addressing the problem of air quality (Mustafa and Najib, 2008).

The problem of air pollution caused by vehicles has, however, not been studied in the city of Tripoli, Libya, before the identification of the main affecting factors that have contributed to the problem, as well as its effects on health, the economy, and the environment. There is a need also to assess the status of air pollution from cars in the area and to discuss the alternative options for resolving the problem, including the need to fill the gap of a comprehensive strategy to address the problem in the study area.

The study area is Tripoli, which is the capital of Libya, located in the north-coastal zone of the country, and it extends 50 kilometres towards the south-west of the country. Tripoli City is the main centre of the Tripoli region, which includes 12 sub-regions. The population density is approximately 582 people/km2 and the average population growth for the period 2005-201 Owas 2.22% (GAI, 2010).

Tripoli, like all major cities and capitals, is thought to be subject to many environmental problems resulting from different human activities, including air pollution caused by vehicles. The city has witnessed a significant increase in the numbers of vehicles in recent years as a result of the growth of the economy and the lack of control on the import of cars, in addition to the poor infrastructure for public transport, which consists only of taxis in the absence of other means of public transport, such as trams, trains, and large buses. These factors may have led to the occurrence and increase of the problem. The cost of fuel is low and only diesel and petrol are available as fuel, which can emit harmful air pollutants that affect air quality in the city. In addition, many other factors may have contributed to the problem and need to be verified and investigated.

The study area lacks researches and studies concerned with the air pollution problem resulting from vehicles, and suffers from poor data and information relating to this problem, as that has been no priority for studying the problem among the Government, individuals, or concerned institutions, and only a few attempts have been made to address this problem.

The problem could worsen, due to the currently visible scenarios of the absence of control on fleets that increase the number of fleet cars, the poor infrastructure of public transport, weak legislation, and a lack of potential human and technical resources of the relevant institutions, as well as the continued use of polluted fuel in car engines. Consequently, there is an urgent need to investigate and verify the problem and evaluate the status of air pollution caused by vehicles in the study.

An investigation of this problem and analysis of the affecting factors will lead to accessing high-quality data and information that can offer a deeper knowledge of the problem and the related issues, particularly since this problem has not yet been investigated in the study area or in the country as a whole.

1.2.1. Reasons for selecting this problem

The reasons that prompted the researcher to select air pollution from cars in Tripoli as the subject of his research can be summarized under the following points:

i. Air pollution from cars is a real problem that can be observed and affects all residents of the study area, as the extreme increase in the number of vehicles and the increase in the severity of congestion on the roads is clearly visible.

ii. A study of this problem will not be a repeat of a similar one, but will provide an academic contribution to this subject.

iii. The research problem is of great interest to the researcher, as he has worked in this field for nearly 20 years and was responsible for the administration's competence to pursue this issue in the study area.

iv. The research problem is limited in scope, in terms of the place and the time period, which gives the researcher a greater opportunity to study the phenomenon on a small scale and across a specific time period, and then disseminate the results to similar areas. These factors will promote the success of the research in terms of rationalizing the use of the resources, time, and focus.

v. The research problem fits the social, economic, political, and cultural conditions of the study area, as it does not conflict with the values of society, and its laws do not affect security or political aspects, which facilitates and simplifies the mechanics of the data collection and provides a greater opportunity for the researcher to engage in various aspects of the problem without restriction.

vi. The research problem has not received the necessary degree of attention from the concerned authorities, the Government and the population. It is therefore worthwhile to that area to spread the knowledge and awareness of the issue and to attract attention at government level, which would help the decision-makers to take the necessary measures to address the problem.

vii. The research problem has many dimensions: health, environmental, and economic. This would open up prospects for the research and study of various aspects, which would mean that, following the completion of this study and the reporting of its results, other researchers might be stimulated and encouraged to study various aspects of the problem, opening up new horizons for research and also for decision-makers.

1.2.2. Personal motivation for conducting this research

The researcher graduated from the Department of Meteorology, Faculty of Science, in Tripoli in 1987, and obtained a postgraduate diploma in

Environmental Management in 1996 from the University of Dresden, Germany. In 2008, he obtained a Master's Degree in Environmental Science. The researcher began his career working for the Environment General Authority (EGA) in Tripoli, Libya, in 1989, and continued working there until the end of 2008. He was a research assistant in air pollution protection until 1997, before being appointed manager of the Department of Pollution Control in 1999, manager of the Inspection and Environmental Monitoring Department in 2004 and, in 2005/06, manager of the Technical Consultation Office. He finished his work at the EGA as manager of the Department of Protection of the Environment from Pollution, in December 2008. The functions exercised by the researcher included the preparation and proposal of the necessary plans and programmes to protect the environment from various sources of pollution, controlling and monitoring air quality. The researcher was also a member of several committees, including developing the structure of the EGA and amendments to the National Environmental Law 7/1982, which was amended by Law No. 15 of 2003, the prepared national reports on the environment in 1989, 1990, and 2002, the latter being the Libyan National Report submitted to the Earth Summit held in Johannesburg, South Africa, in 2002. The researcher was also the representative of the EGA on the Committee on the Creation of Technical Conditions for Imported Vehicles, a member of the Environmental Magazine Committee, and a member of the National Committee for the National Programme for the Improvement of the Environment 2006-2011. He was a member of the National Committee on Climate Change, and a member of the Committee on the Peaceful Uses of Outer Space. In addition, he was the national delegate at the Global Climate Change Convention and the Montreal Protocol for the Ozone Layer.

With all of this academic and practical experience obtained over almost 20 years in Libya, the researcher has a clear overview of the issue of air quality at the national level and has garnered knowledge about many administrative, legal, technical, and institutional aspects of the subject of air pollution by cars. This made the researcher select the subject of traffic air pollution problems to examine this area more extensively and gain even further understanding of the issues and factors affecting the phenomenon of air pollution caused by cars in Tripoli, as well as reviewing the latest scientific developments in this area for the purpose of evaluating the status of traffic air pollution in the study area.

The researcher believes that this research will fill the gaps in the data and information on the issue of air pollution from cars in the study area at the national level, where currently no such data and information are available at all.

1.3. Aims and objectives of the research.

1.3.1. Aims

The main aims of the research are to investigate and evaluate the air pollution caused by motor vehicles in Tripoli, Libya.

1.3.2. Research objectives

i. To investigate the occurrence of air pollution problems caused by motor vehicles in the city of Tripoli, Libya.

ii. To identify the main affecting factors that contribute to the occurrence of an increase in the problem of air pollution caused by motor vehicles in the study area.

iii. To evaluate the current status of the concerned institutions, national legislation, plans, programmes, and actions already taken to reduce traffic air pollution in the study area.

iv. Creation of a local database on vehicular emissions in the study area.

v. Verification of the significant roles of vehicle technology, fuel technologies, and public-transportation-sector reliance as one of the available alternatives for the reduction of traffic air pollution, and support the use and improvement of these mechanisms.

vi. To develop and apply a framework for the evaluation of air pollution caused by motor vehicles in the city of Tripoli.

vii. To suggest available options for addressing the problem of air pollution caused by vehicles in the study area and the instruments required for developing a management strategy for air pollution caused by vehicles in the city of Tripoli.

1.4. Research questions

The research questions passed through several stages of adjustment and change according to what was understood and accessed by reviewing previous studies related to the research topic, and also in light of the researcher's knowledge and previous experience in this field and the views and comments of some specialists and interested parties. Based on all of these procedures, the study tries to answer the following questions:

- How can the status of air quality in Tripoli be described and what are the main sources that may cause air pollution phenomena in the city?

- How does the use of motor vehicles contribute to air pollution?

- To what extent does traffic air pollution occur in Tripoli and what are factors that have led to this environmental problem?

- How is air pollution caused by motor vehicles relevant to health, environment, and economic matters?

- What actions have been taken to reduce traffic air pollution? Are there any policies, plans, legislation and programmes relevant to addressing the air pollution caused by vehicles in Tripoli?

- Why should people decrease their reliance on private vehicles as a means of transport? And how can that be achieved?

- What are the available options that should be taken to reduce air pollution caused by motor vehicles in Tripoli city?

- What are the instruments required (technical, institutional, economic, social, plans and policies, etc.) to develop management strategies for traffic air pollution?

- How could the framework be applied to test various scenarios for evaluating the air pollution caused by motor vehicles in Tripoli.

1.5. Significance of the research

The significance of this research is that, for the first time in the study area and at a national level, the research provides a comprehensive study of an issue of environmental significance that affects everyone. The research provides large quantities of data and information about the relations of complementarily of the problem of air pollution from cars and the affecting factors, which can be utilized by individuals and concerned institutions. It will be useful for students, researchers, and scientists, in addition to those interested in the field of transportation, planning, traffic police, environmental issues, health issues, and also laws and legislation. The significance of this research is that it offers solutions and proposals to address the problem, and this will help decision-makers and institutions to take appropriate measures to address the problem. A significant contribution is the pioneering provision of a database on annual vehicular emissions in the study area, which will be useful at a local level to monitor the scale of pollution in the region. It will also be useful at the regional level, through addressing a vacuum suffered by the country in the field of the provision of environmental data and also its commitment to providing such data to the regional centres and relevant conventions on air pollution control.

The research provides a theoretical framework for assessing the status of air pollution from cars, which can be circulated and used to assess the status of air pollution from cars in other cities in the country and other regions, which have similar conditions.

Lastly, the research opens wide horizons for scientific research in other areas related to the problem of traffic air pollution, including the study of air pollution in the city resulting from other sources, such as waste disposal, industrial activities, and power-generation, as well as other pollutants emitted from vehicles, such as noise, waste oil, and scrap; the relationship between air pollution emitted by cars and various diseases, as well as the environmental and economic impacts of pollution resulting from vehicles.

1.6. Research method

This research was completed in six major stages, of which the first was a review of the previous studies on air pollution from motor vehicles in order to obtain more in-depth knowledge of the research topic and to develop a framework for the study. The second phase involved the collection of the required data for the research, through personal interviews and questionnaires. Also, in this stage, an inventory was taken of annual vehicular emissions in the study area. The third phase was the analysis of collected data and information. The fourth stage was a discussion and interpretation of the results of the analysis of the data, while the fifth stage was the valuation of the problem of air pollution from motor vehicles in the study area through developing, validating and applying the framework. Finally, the sixth stage of the research was devoted to proposing alternative options for reducing the air pollutants caused by vehicles in the study area in order to help decision-makers and those interested in the development of strategies for the management of air pollution caused by vehicles in the city of Tripoli.

1.7. Thesis organization

This research is organized into ten chapters in order to achieve the objectives of the research. The thesis chapters are divided as follows:

Chapter one presents an overview of the problem addressed by the research and the reasons for choosing this problem. The chapter also reviews the objectives of the research, research questions, significance of the research, and research method, and concludes by presenting the structure of the thesis.

Chapter Two presents a literature review, including the basic concepts related to the topic of the study, the most main affecting factors that have played a significant role in the occurrence of air pollution caused by cars; the health, environmental, and economic effects resulting from exposure to traffic air pollution as well as alternative options for reducing the pollutants emitted from vehicular engines.

Chapter Three explains the research approach approved, including the research's epistemology and theoretical perspective. It also explores the research methodology and practical approach to achieving the research objectives.

Chapter Four reports the direct observations made during the fieldwork visit to the study area in July-September 2010, as well as the information gathered from reports and documents issued by the relevant institutions

Chapter Five contains an inventory of annual vehicular emissions for the period 2005-2010 in the study area, compiled with the aid of COPERT software. It also includes measurements of the concentrations of vehicular emissions from traffic congestion in the area of the city centre, compiled during the fieldwork visit to the study area.

Chapter 1	Thesis Introduction
Chapter 2	Air pollution caused by vehicles - an Overview
Chapter 3	Research Methodology
Chapter 4	Field work observations
Chapter 5	Vehicular Emission Inventory
Chapter 6	Analysis of Questionnaire
Chapter 7	Analysis of Interviews
Chapter	Discussion of Findings
Chapter 9	Application of the Framework
ChapterIO	Conclusion and recommendations

Figure 1.1 Thesis organization

Chapter Six presents an analysis of a questionnaire that elicited the views and opinions of the respondents concerning the air pollution caused by motor vehicles in Tripoli. SPSS Software was used for the analysis.

Chapter Seven presents an analysis of the qualitative data collected through interviews with ten experts and responsible people from the three concerned institutions.

Chapter Eight contains a discussion and interpretation of the evidence obtained from interviews, questionnaires, direct observations, and the literature review, together with the researcher’s conclusions.

Chapter Nine presents the application of the developed framework for testing the various scenarios of the status of air pollution caused by vehicles in the city of Tripoli for the future based on different parameters.

Chapter Ten contains a discussion of the findings of the research and reflections on its significance, uniqueness, relevance, and contribution. At the end of the chapter, some relevant recommendations will be presented in terms of resolving the affecting factors that have led to the traffic air pollution problem in the study area, as well as recommendations regarding other relevant issues relating to the topic. These recommendations and suggestions are categorized into several groups according to the objectives and findings of this research.

1.8. Chapter summary

This chapter has presented the research problem and has reviewed the reasons for choosing air pollution caused by vehicles as the topic of this research. It has pointed out that air pollutants result from cars, and their consequences for health, the environment, and economics, and has reviewed the aims and objectives of the research, which focuses on investigating air pollution caused by vehicles in Tripoli and the factors that contribute to this. It also presented the research questions. It ends with an overview of the thesis organization and the chapter summary.

Chapter Two

Air Pollution Caused by Motor Vehicles - an Overview

2.1. Introduction

The purpose of this chapter is to facilitate understanding of the background to the topic of air pollution caused by motor vehicles through conducting are view of previous studies. Most of this literature originated in developed countries, with a few studies being carried out in developing countries. There was a lack of research, studies and reports on the topic of the study area and the whole country of Libya, with very few articles and national reports related to the topic.

This chapter presents an overview of urban air quality and air pollution caused by vehicles, before presenting the factors affecting air pollution caused by motor vehicles, vehicular pollutants, the effects of vehicular emissions, the available options for reduction as well as the instruments required for development strategies. The chapter concludes with an explanation of the proposed conceptual framework.

2.2. Urban air quality

Air pollution in many developing countries is still a severe environmental problem, and many cities in the world are subjected to high levels of this phenomenon. The major sources of damage to air quality in developing countries include population growth, which leads to unplanned urbanization and industrialization (Ozden et al. 2008). This is consistent with what was stated by

Bickersta and Walker (1999), who said that air pollutants are a rising environmental problem due to the existence of some sources, including the increase in the urban population, uncontrolled industrial activities and emissions of pollutants from motor vehicles. Mayer (1999) believes that the emission of air pollutants is caused by different anthropogenic processes which can be categorized into the following source groups: motor traffic, industry, power plants, trade, and domestic fuel. Fenger (1999) indicated that approximately 3000 different air pollutants have been recognized, the majority of which are emissions of organic substances derived from the combustion of fuel, particularly in motor vehicle engines, which emit 500 different compounds. However, the investigations into the impact of these emissions included only two of these pollutants. Komjim and Love (2001) stated that, globally, between 0.5 - 1 million people die at an early age every year as a result of exposure to urban air pollutant gases emitted from private vehicles as well as respiratory diseases.

The developed countries have already made several efforts and taken action to obtain better air quality by creating air quality strategies which have involved many issues, such as an inventory of emissions, air quality regulations and standards, the establishment of air quality monitoring systems in urban and industrial locations and a shift to the use of cleaner fuels such as natural gas (Baldasano et al, 2003). However, Gurjara et al. (2008) point out the lack of air quality data for several developing countries and other data gaps, such as the lack of availability of comprehensive emission inventories. These limit the efforts of governments to resolve urban air pollution. Some guidelines, regulations and emissions standards on air quality levels have been issued by international organizations, while criteria issued by other countries have been created with the aim of protecting air quality around the world (Baldasano et al. 2003). The technical reports published by EGA showed that there is lack of continuous measurement of air pollutants caused by vehicles in Libya (EGA, 2009).

2.3. Air pollution caused by motor vehicles

Land transport plays a significant role in people's life, as a means of facilitating connectivity with schools, universities, economic centres, shopping and work places as well as family visits and excursions. It also provides employment opportunities for workers in the road transport sector and workers in workshops for the maintenance and repair of vehicles and for bus and taxi drivers. Therefore this sector is an indispensable element in people's daily lives. However, it is not considered sustainable as it has effects on health, the environment and climate change, resulting in pollution, noise and traffic congestion as well as accidents (Claus and Wietschel, 2008; Gorham , 2002). Briggs et al. (1997), Xianglu and Luke (2006), D'Amato et al. (2010), Baldauf et al. (2009) and Ting and Shaodong (2009) have stated that emissions from land transport contain toxic gasses which cause air pollution. Motor vehicle emissions include nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM) and sulphur dioxide (SO_2) as well as volatile organic compounds (VOC) which are primary pollutants. In addition, some secondary emissions may occur as a result of the interaction between the primary pollutants and other elements such as Ozone (O_3). Brock et al. (2007) stated that land transport is the main contributor to atmospheric pollution as a result of fuel combustion in vehicle engines, the direct and indirect evaporation of fuel from the car during through refuelling operations, as well as fuel production.

Goyal et al. (2006) confirm the contribution of vehicles to urban air pollution, stating that, compared with the other sources of air pollution, in big cities, land transport accounts for 70% of the total emissions of CO, 50% of HC, 30-40% of NOx, 30% of PM and 10% of S02. More details on the effects of motor vehicles were provided by Briggs et al. (1997), who stated that motor vehicles have serious effects including: health problems such as cancer, respiratory system illness, genetic mutation, blood toxicity and others; environmental effects including climate change, damage to ecosystems and the landscape; and economic effects including an impact on tourism, and reduced crop production. Also.Faiz et al. (1996) believe that there are economic costs that result from air pollution caused by motor vehicles, including damage to buildings and historic monuments, detrimental impact to crop production and loss of landscape view.

The number of private cars in Tripoli increased from 485,136 vehicles in 2005 to 809,815 vehicles in 2010, with an average annual increase in the period 2005-2010 of 10.86%. The number of vehicles per capita was 610 vehicles/1000 persons in 2005, which increased to 879 vehicles/1000 persons in 2010. Some of these cars were made in the period from 1980 to 2000 (DVR, 2010). Table (2.1)below shows that the quantity of consumed fuel by vehicles in Tripoli, which was 671,693 metric tonnes in 2005, increased to 998752 metric tonnes in 2010 (BC, 2010).

Vehicles types	2005	2006	2007	2008	2009	2010
Private Car	485136	564182	650488	705025	752266	809815
Truck	97459	107044	116354	120599	124334	128711
Public Taxi	30594	34880	40412	43740	47389	50234
Tractor	503	539	572	589	595	703
Trailer Truck	9960	11653	13183	13402	13541	14912
Traction Lorry	5390	6667	7948	8174	8323	8778
Winches	5867	6616	7528	7790	7870	8729
Motorcycle	394	446	534	563	603	771
Total	635303	732027	837019	899882	954921	1022653

Table (2.1) Total numbers of vehicle fleet in Tripoli 2005 -2010 (DVR, 2010)

Year	Fuel Consumption (Metric tonne)	Total Vehicles	Fuel consumed by Vehicle (metric tonne)
2005	671693	635303	1.057
2006	725732	732027	0.991
2007	805533	837019	0.962
2008	870107	899882	0.967
2009	952634	954921	0.998
2010	998752	1022653	0.977

Table (2.2).Total fuel consumption in Tripoli 2005 - 2010 (BC, 2010)

2.4. Factors affecting air pollution caused by motor vehicles

There are many factors and aspects to be considered, including the location of the pollutant emissions from vehicles, the creation of secondary pollutants and their environmental impacts, as well as the relationship between these pollutants and the traffic conditions on the roads. Such factors can determine the path and behaviour of pollutants in the atmosphere in terms of their transportation, dispersion and diffusion or stability in the traffic area, depending on three main components: the characteristics of the vehicle, the operating conditions and the weather conditions (Park, 2005). Similarly, Faiz (1990) stated that the increase in the extent of damage to health and the environment that resulted from vehicle pollutants is directly proportional to the increase in land transport and fuel consumption, particularly in the cities, which are characterised by high population density and traffic density on the road network. Some cities could be suffering more than others because their economic conditions do not enable them to establish control systems for motor vehicle emissions. The affected factors include increased private car ownership, changes in city demographic profiles, the time and duration of exposure, including the duration of stay inside a vehicle, physical activity level, and age and health conditions (McKeown, 2007). In addition, Gorham (2002) drew attention to the high volume of use in the transportation sector, the types of technologies used in vehicles, fuel consumption, weather conditions, and topographical conditions. This is consistent with Bindra and Hokoma (2004), who highlighted the great increase in the number of motor vehicles and fuel efficiency. El-Fadel and Bou-Zeid (1999),Goyal et al. (2006),Ozden (2008) and Atash (2007) agree that the most important of these factors is the increased population, which has led to unplanned urbanization in cities, and increased industrial activities without any regard for the physical characteristics of the regions, including the topography and weather conditions In addition, the increase in the number of vehicles and traffic congestion with limited road networks is the main source of essential air pollutants in developing countries.

2.4.1. Population growth

Marshall et al. (2005) have suggested that the increase in population in the urban areas may have an impact on the increasing rates of emissions, and that emissions usually vary according to the urban population as well as the nature of population growth. Faiz (1990) indicated that the population density in areas near to roads suffers greater exposure to these pollutants. Similarly, Bickersta and Walker (2001) assert that the growth in urban population plays a significant role in air pollution. Baldasano et al. (2003) provide more details, stating that one of the main factors leading to the existence of air pollution in cities is population growth, as the people living in the cities of developed countries represent more than 75% of all people in developed nations. Urbanization in the developing world is accelerating and considerably more people live in cities compared with 50 years ago. Marshall et al. (2005) suggest that the density of the population either leads to an increase or decrease in the amount of pollutants emitted by vehicles, depending on the variation in population density.

The population in Tripoli has gradually increased, from 1,041,146 inhabitants in 2005 to 1,065,405 inhabitants in 2006. In 2008, the population was at 1,113,671, making the rate of population growth 2.22%. In 2010, the population increased by 2.12% to 1,161,960 inhabitants. The average population growth for the period 2005-2010 was 2.22%. The population of Tripoli city represents 20.85% of the total country's population (GAI, 2010; WB, 2009).

Years	Number of population	Rate of annual increase %
2005	1,0411.46	-
2006	1,0654.05	2.33 %
2007	1,0894.83	2.26 %
2008	1,1136.71	2.22 %
2009	1,1378.38	2.17%
2010	1,1619.66	2.12 %

Table (2.3) Population growth and the annual increase (%). (WB, 2009)

2.4.2. Economic growth

Atash(2007) stated that the increased economic activity has contributed to the increased air pollution rates in the major cities of developing countries This is supported by Faiz (1990), who notes also that some cities could be suffering more than others because their economic conditions do not enable them to established management and control systems for motor vehicle emissions on the roads and streets. Bekir and Surhid (1997) stated that the level of vehicle ownership is closely associated with economic growth, particularly the per capita income, increases in which seem to be a contributory factor behind the increase in the size of the motor vehicle fleet. The gross national income per capita in Libya has developed from 7628 US dollars in 2005 to 16510 US dollars in 2007 and continued to increase in 2008, reaching 16700 US dollars. In 2009, the total income per capita in Libya was 16750 US dollars (WB, 2009).

2.4.3. Increase in the size of the vehicle fleet

Bindra and Hokoma (2004) stated that one of the most influential factors leading to traffic air pollution is the great increase in the number of motor vehicles and increased fuel consumption by motor vehicles' engines. This view is consistent with Faiz (1990), who stated that the increased damages to health and the environment which may resulted from vehicle pollutants is directly proportional to the increase in the number of vehicles. Cervero (1988) focused on the increase in use of private cars as a factor affecting traffic air pollution. Similarly,Atash (2007) stated that the growing numbers of vehicles on the road networks in cities contributed to the increased air pollution rates in the major cities of developing countries. Dietrich (1997) estimated the size of the world's vehicle fleet to be about 1.8 cars per 1000 persons and, with the inclusion of private cars, trucks and buses, about 2.3 vehicles per 1000 persons. The number of cars per 1000 people in all countries of the world is expected to grow, especially in developing countries, particularly African Countries and a large part of Asia. Park (2005) added that the affected factors include the types of vehicles and technical requirements, as well as the efficiency of engine performance.

The number of motor vehicles in Tripoli increased from 635,303 vehicles in 2005(which is 610 vehicles/1000 persons) to 732,027 vehicles in 2006 (which is687 vehicles/1000 persons). The total vehicle fleet in 2007 increased to 837,019 vehicles, representing 768 vehicles/1000 persons. In 2008, the total vehicle fleet reached 899,882 vehicles, amounting to 791 vehicles/1000 persons. In 2009, the total number of vehicles increased to 954,921 vehicles, or 839 vehicles/1000 persons, and in 2010 the total vehicle fleet was 1,022,653 vehicles, representing 879 vehicles / 1000 person. The private vehicle fleet in Tripoli represents 79.07% of the total vehicle fleet in Tripoli and the average number of vehicles per capita for the period 2005-2010 was 762 vehicles/1000 persons (DVR, 2010).

2.4.4. Increased fuel consumption

Komjim and Love (2001) and Latham et al. (2001) have stated that the type of fuel plays an important role in determining the type of pollutants emitted from vehicles. Fuels which contain lead compounds can cause lead emission, while some fuels have high sulphur content; both pollutants cause damage to health and the environment. Kenworthy and Laube (2002) and Cervero (2000) refer to the role of the fossil fuels used in vehicle engines and note that such fuels pose great risks to health due to the pollutants emitted from their use in vehicle engines. Compared with petrol, diesel vehicles have comparatively low emissions of hydrocarbon from crankcase as well as the evaporative losses while the carbon monoxide and HC emissions are also lower. The percentage of NO emission is, however, high; also, diesel vehicle exhausts emit particulates, including oxygenated hydrocarbons (Bindra and Hokoma, 2004).

The quantities of fuel consumed by vehicles were 671,693 Mt in 2005, increasing to 605,875 Mt in 2006, an annual increase rate of 09.60% while, in 2010, this was 998,752 Mt, representing an annual rate increase of 04.84%. The average quantity of fuel consumed by all vehicles in 2005 was 1.057 Mt/car/year and in 2010 it was 0.998 metric tons/year (BC, 2010).

2.4.5. Lack of public transport.

There is an urgent need for developing countries to construct a strategy concerning public transport management, which is one of the key issues in improving air quality and reducing the pollution caused by vehicles. Such a strategy includes reducing the rates of vehicle fleet growth and use of private cars. Public transport must be attractive and sufficiently alluring to make people reduce their dependence on private cars and accelerate the trend towards the use of public transport. This strategy could be effective if planned and implemented properly, and can address the problems of traffic congestion on the roads as well as reducing the air pollution emitted by vehicles (Gorham, 2002). Sarath et al. (2003) confirm the importance and role of public transport in reducing the problem of air pollution from cars, stating there are many means of transport that can contribute towards reducing vehicle emissions, including trams, buses and public taxis, which could provide an effective solution to the problem.

The public transport fleet in Tripoli in 2005 contained 30,594 taxis, representing 4.82% of the total vehicle fleet in the city, which was estimated to be 51657 taxis. In 2010, this represented 5.05% of the total vehicle fleet in the city (DVR, 2010).

2.4.6. Weakness of the local environmental legislation

Mustafa and Najib (2008) have suggested that the environmental legislation in Arab countries is generally weak, and that most of these environmental laws and standards on pollutant concentrations are based on standards and criteria that have already been applied in developed countries which, in most cases, are inappropriate and do not reflect the environmental situation. Also,Faiz(1990) mentioned that damage to health, the environment and economy is related to non-compliance with the laws and a failure to implement environmental legislation governing the concentration of pollutants. Park (2005) noted that several developed and developing countries have issued legislation, national laws and specific standards regarding the concentration of pollutant emissions from vehicles.

In Libya, the first environmental Law, "Environment law 7/1982",was issued in 1982 and amended in 2003. The act is the only comprehensive national environmental law and contains six chapters detailed in 75 articles. The second chapter concerns the protection of atmospheric air. Two articles in Chapter Two deal with traffic air pollution. Libya has no specific law on air quality issues (EGA.2009). There are no national standards for air pollutants and so Libya usually applies the standards of Arab and European countries, as well as the standards issued by the WHO and UNEP. A proposal was issued by EGA in 2005 about air pollutant standards, which included only two vehicular pollutants; namely, hydrocarbons and carbon monoxide, but this proposal was not considered as the standards for air pollutant concentration and has not been implemented. Traffic law number 11, issued in 1984, concerns traffic on the road network. It has not been developed and amended over the last few years and does not deal with the environmental aspects of road transport. The traffic law deals only with matters of vehicle safety. The law contents six chapters, with eighty articles, all focusing on traffic and vehicle safety.

2.4.7. Increase in traffic congestion

The phenomenon of traffic congestion on the roads is one of the main factors responsible for increasing the amount of emissions from cars and this necessitates strategies to improve road capacity (Sarathetal.2003). The role of traffic congestion in creating pollution from vehicles is also stated by Irving and Morcrieff (2004).

McKeown (2007) has noted that the highest exposure to pollutants occurs in the large cities with a high traffic density on the road network and high intensity of trucks along the highways. There is a strong correlation between traffic volume and air pollution, and it has often been assumed that the management of traffic congestion would reduce both noise and emission levels (Chin, 1995). The lack of improvement in the situation with regard to air pollution caused by vehicles in cities has led to an increase in diseases associated with pollution, especially in crowded cities, where there is widespread traffic congestion on the road network (McKeown, 2007). In Libya, speed limits for cars were issued under the terms of the traffic law but, because there is no commitment to these speed limits, this led to increased traffic congestion in the city. In addition, these speed limits became law in 1984 - over 30 years ago -and so are inconsistent with the reality of the current traffic levels.

2.4.8. Weather conditions.

Faiz et al. (1990) stated that climatic factors have an impact on pollutants in terms of dilution, dispersion, and also the stability or transportation of the air pollutants emitted. The main elements responsible for temporal variations are wind speed and direction, atmosphere stability, sunlight, the intensity of solar radiation, rainfall and temperature. If the atmosphere is stable, it tends to increase concentrations of pollutants in the lower atmosphere, while instability tends to reduce the concentration of pollutants. Komjim and Love (2001) stated that, with regard to the stability, diffusion and dispersion of pollutants, many factors play an essential role, including the time, duration and location of exposure.

Some developing countries such as India and Iran have a special situation with regard to the length of daily temperature inversion, which is reported to take place for more than 50% of the days per year and over six hours a day for more than 90% of the time in the wintertime (Bindra and Hokoma, 2004). This causes a high concentration of pollutants in areas surrounding the contamination sources due to the limited dispersal of pollutants. The authors added that this phenomenon has also been noted in the cities of El-Khoms and Misurata in Libya. Heat, sunlight and humidity have an influence on the reactions of vehicular air pollutants that may occur in the atmosphere, as well as the amount of evaporation of VOCs from vehicles and refuelling systems (Gorham, 2002).

Tripoli is located between two types of climate: the desert climate which is characterized by high temperatures and warm air currents and the Mediterranean climate which is characterized by moderation in temperatures and increased relative humidity which is higher in the cities during the summer. The study area suffers from a significant increase in temperature during the summer, reaching 47°C with no wind able to transport the air pollutants out of the traffic-congested areas in the city. The high temperature contributes to the stability of the atmospheric air in the summer and keeps the vehicular emissions in the region of the traffic. The air is stable during most seasons of the year with no strong winds and currents which can transport pollutants away from traffic-heavy areas (NCM, 2008).

2.4.9. Lack of public awareness

Public awareness and people's understanding of how their behaviour and individual decisions affect air quality is considered an important factor when making decisions and implementing plans concerning traffic air pollution issues (Gorham, 2002). Increased public awareness about the damage caused by air pollution will help to combat the risks of air pollution (Sarath et al. 2003). The public awareness of the effects of air pollution is still below the required level all over the world, although some activities have been carried out by certain groups to raise awareness, include a variety of meetings, providing publications and brochures, distribution of leaflets, posters as well as seminars, workshops and other media (Bickersta and Walker, 2001).

2.5. Pollutants emitted from vehicle engines

The classification of pollutants into primary and secondary pollutants depends on the method of emission and whether it is directly from the source or formed in the atmosphere (Seinfeld and Pandis, 1998). Pollutants emitted from vehicles can be divided into three different groups: hot emissions, cold emissions and evaporation emissions (Reynolds and Broderick, 2000).

Pollutants are emitted through three parts of a vehicle; namely, the crank case, the fuel system and the exhaust (Park, 2005), but exhaust gases are the major source of pollutants. In addition to these air pollutants, there is a quantity of dust produced from the gradual wearing away of the rubber tyres, brake linings and clutch plates of the vehicle. Combustion and oxidation in the engine also produce water and carbon dioxide (Watkins, 1991). The major pollutants released from petrol engines are carbon monoxide and nitrogen oxides through vehicle exhausts, along with hydrocarbons which emanate from different parts of the vehicle, including the vehicle exhaust, crankcase and fuel system, and from the atmospheric venting of vapours through the stage of the distribution and dispensing of fuel (Faiz et al.,1996), together with the direct and indirect evaporation of fuel from the car during refuelling operations, fuel production, and key pollutants including ozone, carbon dioxide, volatile organic compounds (VOC), non-methane volatile organic compounds (NMVOCs), the hydroxyl radical (OH) in the presence of reactive nitrogen oxides, and particulates (Brock et al. 2007, Cerver and Kockelman, 1997).

The fine particles, especially those emitted from diesel engines, were considered the majority of the pollutants released by vehicles in the cities of developing countries. In addition to the emission of lead from leaded automobile fuel, and smog resulting from the photochemical reactions of nitrogen oxides in the presence of sunlight, there exist suspected carcinogens such as Benzenel, 1 Butadiene, aldehydes and polynuclear aromatic hydrocarbons from vehicle exhausts and other sources (Daniel and Darrell, 2009). Most of the carbon dioxide emissions in urban areas can be attributed to vehicles (EPA, 2001).

2.5.1. The emissions inventory

To estimate the amount of emissions from vehicles, it is necessary to conduct a survey to collect data about trips, including the average speed per trip, the number of hours travelled by car, and the operation of the engine (Lawrence et el. 2000). Compiling an inventory of motor vehicles' emissions generally depends on a number of important elements, including the travel demand, the degree of congestion on the roads, the functioning of the vehicle engine, the operating conditions of the vehicle, and the characteristics of the fuel as well as the behaviour and culture of the drivers, local climatic conditions, topographical circumstances and others. In general, the identification of vehicle emissions depends on the use of emission factors. While huge data about the main emission factors is available, its applications are still limited as a result of a lack of information about the functioning of motor vehicles (Reynolds and Broderick, 2000).

In developed countries, inventories of emissions are issued by the appropriate national authorities. However, in developing countries, the routine assessment and reporting of emissions in sufficient quality is absent and only available in a few countries. The estimates are often unreliable, contradictory and/or unrealistic. In the majority of developing countries, the ability to make reliable estimates is generally lacking and, without detailed, reliable emission inventories, it is difficult to develop strategic plans to combat air pollution and monitor the efficiency of these plans (Haq and Schwela, 2008). A number of studies have compared the available methodologies for calculating emission inventories.

A large number of parameters are required in order to perform emission inventory calculations for pollutants emitted from vehicles. These parameters include travel demand, traffic conditions, vehicle operating type, vehicle operating conditions, vehicle categories, the kind of fuel and meteorological conditions (Reynolds and Broderick, 2000). Key elements that should be taken into account for the development and implementation of any project or programme to reduce air pollution in cities include the emission factors for each pollutant and the availability of models for estimating the total emissions (Giorgio et al., 2009).

An inventory of vehicular emissions in Tripoli during previous years was unavailable, as there were no studies or researches conducted on such vehicular air pollutants, which may result from the absence of specialized expertise in these areas, in addition to the lack of research tools and the measurement and control to monitor pollutants in this area. An inventory of vehicular emissions is made in this thesis, which included all vehicular pollutants in Tripoli during 2005-2010 which, will be presented in Chapter Five of this research .

2.6. The effects of vehicle emissions

Air pollution in cities is one of the biggest environmental problems facing cities, as this is a source of serious diseases that affect health (Komjim and Love, 2001), environmental damage (Slezakova et al. 2012) and economic effects as a result of the size and cost of the damage. These effects are manifested both in the short- and long-term, as many may not become apparent until after many years of exposure to pollutants. The levels of air pollution in many urban areas in developing countries exceed the required standards and, therefore, this pollution still represents an environmental problem that has health, environmental and social effects in these cities (Ozden, 2008).

2.6.1. Health effects

There is a correlation between the emission concentration levels and the effects of pollution on human health. Concentrations of O_3, SO_2, NO_2 and particulate matter (PM) are correlated with increased respiratory, heart and other diseases (Andres and Guerrero, 2004). However, the identification of the causes of health effects will be difficult where people are exposed to a mix of pollutants. The majority of recent studies suggest that fine particles and ozone are the major causes. There may also be significant direct health impacts of SO_2, while NOx has less effect (Ari Rabl and Joseph, 2000). The health effects resulting from the inhalation of pollutants from cars is one of a number of other effects that are related to motor vehicles and urban planning (Delucchi, 1996). The seriousness and risks of these pollutants change with the age of individuals, as well as their medical conditions (McKeown, 2007).

In a study carried out in Metropolitan Manila, it was found that the levels of particulates in children who worked as vendors in the streets, aged between 7 and 14 years old, were 10% higher during the afternoon, while the levels of lead in the bloodstream were 26% higher than in children receiving education in schools. The results of the study showed that the levels of both particulates and lead were already above the WHO criteria for schoolchildren, by 2.6% and 1.4%, respectively (Gorham, 2002).

Davis et al. (2006) stated that the effect of air pollution on health is shown by the great increase in respiratory system diseases and skin diseases, particularly in children. Rimmington (2006) has pointed out that air pollution from cars is associated with the presence of a number of illnesses as a result of the increased risk of cardiovascular and respiratory diseases, including asthma and bronchitis, eye diseases and the destruction of DNA. There is a closer relationship between the health effects on individuals (mortality and morbidity) and air pollution emitted from motor vehicles. The problem of health risks resulting from the exposure of individuals to vehicles' air pollutants has now become a global environmental issue (Sirikijpanichku et al. 2006).

At the national level in Libya, there is a complete lack of studies and surveys relating to the assessment of the health, environmental and economic effects produced by environmental pollution, particularly pollution emitted from vehicles. This is due to the lack of specialists, data and information about the quantities of vehicular pollutants and the relationship to various diseases.

2.6.2. Environmental Effects

DEFRA (2007) mentioned that the environmental effects of urban air pollutants occur due to the direct impact of pollutants on buildings as well as the transport of air pollutants to housing and offices, the transmission of certain pollutants to agricultural areas close to cities or located besides highways, the negative effects on the fertility of the soil and open water sources, and the poor growth of crops.

Regarding the impact on vegetation, the vulnerability of sensitive plants to heavy metals such as lead can cause changes to plant tissue, leading to death in many cases. In addition, there is an impact on forests; a total of 1-4 million dollars/year are lost in Asia as a result of air pollution and up to 6 million dollars annually in the Newly Independent Countries (Komjim and Love, 2001). The effects of air pollution on plants depend on several factors, including the type of emissions, plant type, soil conditions and climatic conditions. The effects are lower when the exposure to air pollutants is low but, as the level of exposure increases, many effects can be observed, including on plants as well as plant growth, the quantity of pollen formed and the quantity of allergenic proteins contained in that pollen (D'Amato et al. 2002).

2.6.3. Global warming

Road transport is the largest source of greenhouse gases within the transport sector, although road transport is not solely responsible for greenhouse gas emissions (Sarath et al. 2003). The transport sector, therefore, affects the global climate (Weiss et al. 2000; Mizsey and Newson, 2001; Johansson, 2003).

In turn, climate change impacts on air quality through ventilation, wind speed, the depth of mixing, and convection in addition to precipitation, dry deposition, the production of various chemicals and the rate of loss, and persistent natural background concentrations of emissions (Jacob et al. 2009). According to the Kyoto Agreement, the causes of CO_2 emissions have been allocated to the transport sector (Bates et al. 2001).

2.6.4. Economic Effects

The economic effects of air pollutants from vehicles include effects on the style and standard of living and the impact on the tourism sector. In addition, visual pollution lowers the total value of urban land and the financial value of real estate and farms that are exposed to pollution, while acid rain caused by emissions of sulphur dioxide can affect buildings and vegetation. Air pollution promotes a greater reliance on the use of air conditioners in vehicles, homes and offices, which leads to increased energy consumption, with the accompanying financial implications (Sirikijpanichku et al.,2006).

The assessment of the economic effects of vehicle-derived air pollutants also includes the cost of damage to health. Health outcomes can be evaluated using a number of methodologies which assess treatment costs, lost productivity, pain and anguish in addition to the cost of protective equipment (McKeown, 2007).

Information concerning the effect of air pollutants on ecosystems and their economic assessment is limited and there is a need to consider the approaches used in impact analyses as well as to determine the affected recipients, which may be people, vegetation, plants, buildings, animals, etc. (Ari Rabl and Joseph, 2000). The cost of the health problems associated with air pollution caused by the transportation sector alone has been estimated at more than five billion dollars a year in the Arabic region (Mustafa and Najib, 2008). In Libya and Tripoli, as a case study, there has been no survey or researches to define the effects of vehicular air pollution on the economy due to the lack of experts, data and consideration of such issues, as it is not an important issue for the government or concerned institutions in the absence of the required tools.

2.7. Available options for reducing the air pollution caused by motor vehicles

The air pollution in developing countries needs to be addressed by developing rapid and necessary measures to solve this important environmental problem in those countries (Devis et al. 2006). The risk resulting from exposure to vehicle air pollutants is a global environmental issue and many governments take actions and measures to reduce the negative effects of pollutants emitted from vehicles. These actions include the gradual reduction in the use of leaded fuel and control of air quality through improved engine technology, such as the catalytic converter. The measures and procedures applied include issuing standards and criteria to verify the concentrations of the pollutants emitted and also to reduce the rate of sulphur content in motor fuel in addition to controlling and managing the traffic on the road network and the prevention of traffic congestion (Sirikijpanichku et al. 2006). Emission reduction can be achieved through many options, including improving the public transportation infrastructure, continuing to measure vehicular pollutants, and managing traffic congestion by phasing out the use of old vehicles and gradually reducing the use of polluted fuel (Watkins et al. 2004). The creation of guidelines for reducing the sulphur content in motor fuels, and periodic monitoring of air quality all contribute to the significant reduction in the emissions of sulphur and other gases in many cities of the world (Sarath et al. 2003).

The report issued by (EGA,2009) showed that there have been some attempts by the government to address traffic air pollution in Libya in previous years. These actions were very limited and had a limited impact on the status of the problem. The actions already taken by the government to address traffic air pollution included the following procedures:

i. Banning the production and use of leaded fuel in vehicle engines since 2004.

ii. The replacement of Environmental Protection Act 7/1982 with law No. 15/2003.

iii. Building a second Tripoli ring road in order to reduce the severity of congestion in the city.

The National Programme for Environment Improvement 2006-2011 was replaced by the EGA in 2005. This change included several environmental issues related to air quality management. The proposal aimed to address many environmental problems which occurred in previous periods and this programme involved nine projects which were expected to be implemented by 2006 and continue for five years. These projects included controlling and monitoring pollution, an environmental emergency plan, the protection of nature, the integrated management of coastal areas, integrated waste management, environmental education, environmental information, cleaner energy, the development of legislation and international cooperation and an integrated environmental management project.

2.7.1. Improvement of vehicle technology

Vehicle technology includes improving engines to increase fuel burn efficiency which in turn reduces the emission of pollutants. Such technologies include setting up a catalyst system in the exhaust, which is already used in many countries and has proved its effectiveness in reducing the amount of pollutants emitted by motor vehicles (Park, 2005). The control of pollutants from the beginning through increasing engine efficiency can reduce hydrocarbons and carbon monoxide by more than 95% and about 80% or more of NOx emissions compared to non-control lead emissions (Faizetal.1996). Other technical measures include subjecting all vehicles to engine tests to determine the technical efficiency of their engine. Routine maintenance of vehicles is also required to ensure the continued safety of the engines and their efficiency (El - Fadel and Bou-Zeid, 1999).

2.7.1.1. Emission Control Technologies

Technical measures for addressing transport emissions can play an important role in supporting the strategic approaches that have been identified in advance through a deep and careful analysis in addition to economic analysis (Gorham, 2002). The techniques usually used to control exhaust emissions, including the recycling of exhaust gases, the electronic control of engine performance, exhaust treatment devices linked to advanced combustion technologies, and making modifications to the engine alone cannot reduce emissions to a level which is achievable by the presence of a three-way catalyst. Compared to an engine carburettor, the engine control electronics and processes in a three-way catalyst can reduce carbon monoxide emissions from 7.5 grams per km to 1.5 grams per km, the emissions of hydrocarbons from 1.5 grams per km to 0.25 grams per km, and the emissions of nitrogen oxides from 2.0 grams per km to 0.25 grams per km (Faiz, 1990). There are two important factors that will play a vital role in influencing the automotive technology in the future: saving energy and protecting the environment from pollution resulting from cars (Maggetto et al. 1992; van Mierlo et al. 2006). Flowever, the analysis of the past 50 years indicates that the adoption of new technology is relatively slow (Moriaty and Flonnery, 2004).

2.7.1.1.1. Emission control devices

A) Catalytic Converters

The catalytic converter appears to be one of the most effective means of reducing air pollutants produced by internal combustion (IC) engines. The conversion efficiency for CO, HC and NOxmay reach as much as 90-95% under optimal conditions. The conversion efficiency, however, depends strongly on the working temperature (Korin et al. 1999). The catalytic converter, an “end-of pipe” solution, has become one of the most effective technologies. Since the introduction of cars with three-way catalytic converters, the amount of emissions of hydrocarbons, carbon monoxide, nitrogen oxides and other atmospheric pollutants from car exhausts has declined substantially. It is therefore important to investigate whether this technology is reducing the environmental impact from car exhausts locally while increasing the environmental burden globally (Wathanyu and Ramna, 2001). The catalytic converter processes eliminates the smog compounds emitted by motor vehicle exhausts (Soumak et al. 2012). Catalytic exhaust after-treatment technologies for gasoline and diesel-powered vehicles have been developed. These technologies are classified according to engine type, which determines the catalyst operating conditions (Moldovan et al. 2002). In Libya, the fixing of catalyst converters to vehicle exhausts was not required by either traffic or environmental law, nor were these required to be fitted to imported vehicles.

B) Inspection and maintenance (I/M)

Vehicle inspection and maintenance can play an important role in enhancing vehicle performance and implementing emission standards for vehicles. The main aim of inspection and maintenance systems is to recognize polluters and ensure that all vehicles are refurbished or withdrawn from use where the vehicle engine is inefficient, and it should be made difficult to cheat or avoid inspection (Gwilliam et al. 2004). The I/M programme assists with the identification of defects and failures in the implementation of programmes to control car emissions. This programme also contributes towards identifying the equipment and appliances used in reducing pollutants from cars, and is also a key element in designing the minimization of emissions and the effectiveness of measures designed to discourage pollutants. The lack of a strong, effective programme of inspection and maintenance will lead to noncompliance with the vehicle pollutant criteria (Faiz, 1990).

The maintenance and repair of vehicles will lead to the ability to determine the level of efficiency of vehicle engines of both old and new vehicles. However, to enhance the effectiveness of I/M programmes, some actions should be taken, including free pollution checking besides basic servicing at petrol pumps (Goyaletal.2006).

In Libya, the technical inspection of vehicles does not include engine efficiency to ensure its ability to complete the process of burning fuel. Vehicle drivers are not requested to fit vehicles with catalytic converters and imported vehicles are not required to be fitted with a catalyst device. It is noted that EGA and GTL do not have the equipment or devices required to conduct the technical inspection of vehicle engines. In addition, vehicles in the study area do not use catalysts as these are not required for vehicle registration.

2.7.2. Improvements in Fuel Technology

The kind and amount of fuel must be considered in any strategy for reducing vehicle emissions, as well as efficient engines and fixing control devices to vehicles, such as catalytic converters (Goyal et al. 2006). Alternative fuels include gaseous fuels, bio fuels, and electricity. These are more expensive for the end consumer than conventional fuel but greatly reduce the quantities of pollutants emitted by cars, especially when used as an alternative to conventional diesel fuel (Gwilliam et al. 2004). Possible options for alternative fuels include the elimination of leaded fuel, as well as imposing a specific timetable for phasing out the use of diesel engines in private cars (El-Fadel and Bou-Zeid, 1999). The reduction of sulphur content in motor fuel will reduce emissions of sulphur dioxide (Sirikijpanichku et al. 2006). Natural gas was recommended as a significant alternative fuel for reducing local air pollutants, and needs very little processing for use in vehicles (Bolye, 2005). The use of natural gas can reduce the quantities of pollutants such as hydrocarbons, sulphur dioxide, nitrogen oxides and carbon monoxide (Guo et al. 2004).

In Libya, the government issued a resolution to eliminate the use of leaded fuel in 2004, whereby new unleaded petrol and diesel were used by all kinds of vehicles while no unpolluted fuel, such as liquid gas and electricity, was produced or used for vehicles engines in Libya.

2.7.3. Development of Environmental Legislation

For the purpose of controlling pollutants due to the increased fleet of cars, age limits on imported vehicles is an important way to reduce the import of old, dilapidated cars, which emit large amounts of harmful air pollutants. To achieve this, many of the states have developed requirements related to the import of cars, including determining the age of the car. However, in many cases, this procedure leads to an increase in the numbers of old vehicles that are smuggled illegally. Another measure is to review the import duties and taxes to encourage people to opt for importing new cars by lowering taxes on imports (Orlando, 2009). One of the main actions which might help to reduce the amount of air pollution produced by vehicles is to improve and develop legislation, laws and regulations, including environmental and administrative steps, to ensure the monitoring of air quality and maintain the continued control over the different means of transport to ensure compliance with the environmental standards set for allowable concentrations of pollutants from cars (Faiz et al. 1996). The presence of strict laws to protect the environment in developed countries as well as the development of concepts related to environmental problems have helped to prevent and control air pollution and protect of air quality and this is now affecting among some governments in developing countries (Ozden,2008). Despite the strict laws that have been introduced to reduce air pollution from vehicles, field studies confirm that the effectiveness of these laws is not at the required level and that further measures and actions are needed (McKeown, 2007). In Libya, the law no 7 of 1982 on the environment was issued by the resolution of government no 286/1982. This law is considered as among the most important laws on environmental protection, which covered several environmental issues, including protection against air pollution. This law was amended by law 15 / 2003 which involves a chapter on atmospheric pollution, which defined traffic air pollution and the related issues. Still, this section already appeared in law no 7 / 1982, while, no national air quality law was issued (EGA,2009).

2.7.3.1. Development of air quality standards

In order to design an integrated programme to control air pollution from cars, it is necessary to establish standards for permitted concentrations of pollutants emitted from the exhausts of vehicles. Such standards must be based on the evaluation of logical and realistic costs and anticipated benefits, taking into account the technical and management feasibility of the proposed measures (Faiz, 1990). The mechanisms and actions which have been used in several developed countries to reduce vehicle air pollution include the issue of standards and criteria for emission concentrations (Sirikijpanichku et al. 2006). In Libya, vehicular air pollutants standards were unavailable which has led to the use of standards issued in Arab countries and European standards as well as guidelines published by international agencies such as the World Health Organization (WHO) and United Nations program for the Environment (UNEP). In 2003, the EGA issued proposed guidelines for air pollutants, included air pollutants traffic air pollutants were involved, which included only hydrocarbons and carbon monoxide emitted from gasoline fuel, as shown in Table 2.4. These values are not considered as standards and still use the regional and intentional standards (EGA, 2009).

Fuel type	Pollutants emitted	Vehicles manufactured before 2003	Vehicles manufactured after 2003
Gasoline	HC	900 ppm	600 ppm
	CO	4.5%	2.5%

Table (2.4) The national guidelines on pollutants emitted by vehicles (EGA, 2009)

2.7.4. Supporting the responsible Institutions

The local authorities should promote and push for the adoption and execution of national policies to control the excessive use of private vehicles for transport (Faiz, 1990). The institutions suffer due many problems at the level of institutional building and capacity, in addition to the lack of qualified staff and technical expertise (Mustafa and Najib, 2008). There is an urgent need for increased support and to strengthen the institutions responsible for environmental management and pollution control through the development of their organizational structure, increasing the number of their employees and enhancing the ability of their employees through a focus on continuous training, the provision of laboratories and equipment and the establishment of monitoring stations at various sites (El-Fadel and Bou-Zeid,1999). Air pollution management necessitates building a national capacity to carry out the tasks to measure pollutants and conduct analysis and surveys of environmental pollutants, as well as the continuous monitoring of contamination through the use of integrated monitoring and control systems and the ability to review the strategies and development. Of course, these tasks require the support of the existing environmental institutions, financially and technically, the development and increased effectiveness of the structures, and the provision of various operating requirements (LAS, 2005).

In Libya, EGA is authorized to develop all of the necessary requirements to ensure the protection of the environment; EGA imported equipment to measure and analyse air pollutants in 1997, but this equipment was never installed or operated for administrative reasons and, in 2010, EGA imported a mobile laboratory to measure air pollutants that may be emitted from different sources, including vehicles. EGA created a department named "Management Control and Protection of the Environment". This department contains a section named the "Department of Environmental Monitoring" and another section called "Combat of Air Pollutants". These two sections have technical staff, including five engineers who graduated from Libyan universities. The technical staff in this department received short training courses on conducting studies and research regarding air pollution, but did not receive any comprehensive training on how to measure or analyze the air pollution caused by vehicles. In addition, this department failed to conduct any surveys on the sources of air pollution, including air pollution caused by vehicles, until 2010, when they measured the air pollution caused by vehicles in the city of Tripoli. EGA has another department named the "Department of Technical Affairs and Laboratories", whose tasks include the analysis of all pollutants, including air pollutants emitted by vehicles and also the collection of samples from polluted sites. This department has several sections, one of which is named the "Laboratory of Air Pollutants". However, the department co-operates with a section called "The Combating of Air Pollutants", working as a team to collect and analyze air pollutants using the mobile laboratory. They began this work in 2010, although they still need further training in this regard.

The responsibilities of EGA as presented by environmental law No. 15/ 2003 include the following tasks:

1. To conduct periodic measurements of the air pollutants emitted from vehicles.

2. To develop standards for the concentrations of air pollutants.

3. To provide the necessary equipment for the analysis of pollutants.

4. To train and rehabilitate technical staff.

5. To provide the necessary means to raise public awareness of air quality issues.

6. To conduct studies, research and environmental surveys of the sources of air pollution.

7. To implement the Environmental Protection Act.

2.7.5. Development of the public transport sector

There are many means of public transport that can contribute to reducing vehicle emissions, including trams, buses and public taxis, which can offer an effective solution to the problem (Sarath et al. 2003). Consideration of the transport sector is one of the main components of air quality strategy. The main objective is to improve public transport and services and to encourage people to use public transport instead of continuing to depend on the use of private transport. Improving public transport services is more effective than using the price system and tax. The main aim of the policy of improving public transportation and services is to support poor people, while other goals, such as maintaining air quality and reducing the fleet of private cars, are secondary. To achieve all of these goals necessitates providing marketing services for public transport and the development of legal frameworks for the transport sector (Gorham, 2002).

The use of public transportation is extremely important for reducing the energy consumption and environmental pollution reduction caused by land transport

(Shapiro et al. 2002). In addition, walking as well as cycling provide effective alternatives which must be taken into account to encourage people to use non-automobile transport (Sarath et al. 2003).

2.7.6. Raising public awareness

To increase awareness, environmental education is needed for all community groups about the risks of air pollution caused by vehicles and the clarification of the important contribution that can be made by members of civil society through programmes and projects to reduce air pollution from motor vehicles provided by the government institutions in the country (Faiz et al. 1996). Increased public awareness about the damage caused by air pollution will help to combat the risks of air pollution (Sarath et al. 2003). The consent of the citizens and residents to adhere to the plans, programmes and policies designed to reduce pollutants from cars necessarily requires a general understanding of such fundamental issues. Both drivers and non-drivers need to develop an understanding of how their behaviour and individual decisions affect their quality of life. Improved understanding, education and public awareness are required as important issues to ensure the contribution of the public to the decision-making and implementation (Gorham, 2002). However, the public awareness about the effects of air pollution is still below the required level worldwide, despite the fact that certain groups carry out activities to raise awareness. Hence, there is still a need to develop public awareness about the problems related to air pollution from cars through publications, brochures and other media (Bickersta and Walker, 2001).

2.7.7. Improvement of traffic congestion management

Improving traffic management will serve to limit the increase in the quantities and concentrations of air pollutants that may result from traffic congestion (Park, 2005). Most transportation sector organizers are concerned about traffic congestion as a major environmental problem in cities and have recommended pricing policies as a potential way to reduce traffic congestion (Junghwa et al. 2012).

2.7.7.1. Pricing system establishment

Fuel pricing policies as one means of reducing air pollution from cars can take a number of forms, such as energy tax, which is a tax on specific components of the fuel or carbon taxes. This type of pricing is imposed on every car. Pricing can also be used to alleviate traffic congestion in specific areas, or places allocated close to sensitive areas(Anable and Boardman, 2005; Gorham, 2002). There are a number of other options available, which can include road entrance fees and tolls according to the distance travelled based on global positioning technology, where the fees paid depend on the route that a car takes as well as the day of the week and time (Mitchell, 2005).

The positive effects of the London Congestion Charging Scheme have included a reduction in vehicle miles travelled in the zone by 20-25% for the period of charging as well as a reduction in the total car miles travelled in the zone by 10-15%. In addition, this reduction of traffic flow was expected to increase the speed of vehicles in central London from 15 to 8 km/h during the morning peak period (Beevers et al. 2005; Leape, 2006).

2.8. Management strategy on air pollution caused by motor vehicles

The most important steps in developing a strategy to reduce the number of motor vehicles should include the identification of the most important environmental problems and estimations of the potential damage to public health and the environment, taking into consideration the institutional, legislative and human capacity. The analysis of the existing situation is a very important stage in the identification of an appropriate strategy, which must include a number of important issues and necessary matters (Komjim and Love, 2001). Strategies for reducing air pollutants from vehicles include the management of pollutants from road transport, organizing and managing the need for trips and improving the mechanisms for the supply of transportation. Air quality and management strategies in cities require a clear action plan that is divided into several stages (short-, medium- and long-term), setting out clearly what will be managed and implemented in each stage (DEFRA, 2007). The strategy for reducing the damage caused by people's exposure to air pollution problems should involve the following:

i. Technical measures, including vehicle and fuel technology.

ii. The management of transport needs and demands, including incentives.

iii. Economic measures including market incentives, which can encourage and motivate people to resort to public transport.

iv. Improvements and enhancements to the public transport fleet, to give it the capacity to provide encouraging alternatives and so reduce private vehicle use by developing the transport infrastructure (Faiz et al. 1996). An integrated strategy and effective measures to control air pollution in cities necessitates the quantification of emissions and their sources and spatial distribution, as well as the ability to calculate the concentrations of pollutants in the atmosphere (Davis et al. 2006). Based on the information gathered from the EGA report 2008, there was no strategy in place in previous years for managing or addressing the problem of air pollution caused by vehicles in Tripoli. The actions taken were limited and had no significant impact on improving the status of the problem.

2.8.1. Instruments required for alternative strategies

Providing data and information about the health benefits expected from improved air quality will help decision-makers to take measures and issue decisions and instructions to support programmes and projects to improve air quality and reduce the amount of pollution resulting from vehicles. The more accurate the information, the quicker and more positive will be the government's response to supporting programmes for air quality improvement. However, it is very important to take into account that the decision of the government should not depend solely upon the costs and benefits, which are difficult to predict, because some health, social and economic outcomes cannot be valued (McKeown, 2007).

The adoption of a strategy requires the necessary analysis to determine its cost effectiveness. There are many factors influencing the environmental problems related to transport, including the geographical location, climate, social and economic conditions, and human resources. Therefore, the most appropriate solutions will depend on the priorities chosen by the authorities and the extent of their ability and willingness to address specific environmental problems. The, cost-effectiveness of any control measures must take into account the correlation between the cost of relevant factors such as energy, technological development, and the impact on the standard of living (Kojima and Lovei 2001). There may be a need to create a balance and agree trade-offs between the different goals of the strategy, which might interfere with the operations, depending on the most important priorities chosen. One of the biggest obstacles to testing the cost-effectiveness of combating vehicle air pollution is the lack of information and data regarding the costs of the control measures and effectiveness at the institutional and administrative levels in developing countries. In the absence of such information and data, investing resources in programmes to combat pollution is impracticable (Faiz, 1990).

2.9. **DPSIR** (Driving Force - Pressure - State - Impacts - Response) **Analytical Framework for assessing environmental problems**

The DPSIR framework is an analytical framework that recognizes the complexity of environmental interactions and provides a means of analyzing them. The adoption of the DPSIR framework for environmental degradation assessment allows the interconnection of the various indicators to be well-understood. The DPSIR framework is an effective means of organizing complex environmental information for policy formulation and therefore can be applied in other areas with similar environmental problems (Agyemang et al. 2007). The DPSIR framework is a developed version of the PSR framework which was established by Canada at the end of the 1970. The PSR components are "pressure - state - response", where pressure on the environment leads to change in the state of the environment and these changes need a governmental response to take action to treat the environmental problem in question. This framework was developed in 1993 by the OECD into the Driving force - Pressure-State-Impact -Response (DPSIR) framework, in order to provide more comprehensive approach to the analysis of environmental problems. This view of systems analysis indicates that economic and social development, which are driving forces (D), exert pressure (P) on the environment, and therefore the state(S) changes the environment, such as the destruction of natural resources, damage to biodiversity and reduced environmental quality. These changes then have impacts (I) on human health, the environment and economic issues. Because of these impacts, the government, institutions and companies respond (R) to these driving forces, or directly to the pressure, state or impact through prevention or creating solutions to address the problem (Karen et al. 2009). The DPSIR framework is a tool for analyzing environmental problems. The main advantages of using this framework are that it makes it possible to include significant information on the different elements of the DPSIR sequences and also to assess the value of the responses. The DPSIR framework will provide helpful highlights into the association between the state of the environment and the consequences of environmental problems, while at the same time assisting in understanding their dynamics by concentrating on the links between the various elements of DPSIR. The DPSIR framework has speedily become popular with researchers and policy-makers (Mateus and Compzano, 2008).

Driver Forces
Indicators

Response
Indicators

Impact
Indicators

Pressure
Indicators

Figure 2.1 The DPSIR Framework

2.10. The conceptual framework for the evaluation of air pollution caused by motor vehicles

The Information and data from previous studies show that several factors play an extensive role in the emergence and growth of the problem of air pollution from cars. These factors include population growth, economic growth, increases in the size of the vehicle fleet and other factors. Previous studies have confirmed that these factors, if uncontrolled, will increase the scale and risks of the air pollution caused by vehicles. Hence, measures to control and resolve the factors affecting traffic-related air pollution will reduce the concentrations and quantities of the pollutants emitted by cars and therefore reduce the risks to health, environmental and economic aspects as well contribute towards improving the air quality in the study area. To answer the research questions (Chapter 1/ section 1.4), and evaluate the issues related to air pollution caused by vehicles in the study area, a framework has been developed based on the DPSIR Analytical Framework, which was described in the previous section. The developed framework was modified to be suitable for assessing the status of air pollution caused by air pollution in Tripoli city (Figure 2.2).

This framework can be regulated and provides huge amounts of data and information on the problem of air pollution from cars as part of a logical sequence. These data can be used and adapted to analyze the factors affecting the problem of air pollution from cars as well as to study the implications of these. They also provide many options for institutions and decision-makers with regard to addressing the problem.

This framework, which was developed to be appropriate for assessing air pollution from cars, can be employed to investigate the relationship between the various factors affecting the existence of the phenomenon of air pollution from cars, as well as the causal relationship between these factors and the consequent results. This framework helps to identify and test various scenarios related to air pollution resulting from motor vehicles through selecting the test factors that have the most influence on the existence of the phenomenon, as well as a multiple choice test to reduce the amount of pollutants released by cars. This includes reducing the volume of pollutants from cars and their effects through the possibility of assuming various scenarios by changing the parameters, which will lead to the identification of the parameters that have the most influence on addressing or mitigating the problem. This makes it easier for institutions and decision-makers to develop plans and programs appropriate for addressing this problem according to the various scenarios that are tested through this framework

2.10.1. The compounds of the Conceptual Framework based on the DPSIR framework.

The developed framework (based on the DRSIP Framework) works through serial process where socio-economic and institutional factors, which are the Driving Forces (D), exert vehicular emissions (Pressure "P") on the air quality (State "S") which results in changes to the air quality state. These changes in the air quality state will have impacts (I) on human, environment and economic issues. These impacts will elicit government, institutions and local authorities' responses (R) to the driving forces, or directly to the pressure, state or impact, in the form of the provision or creation of solutions to addressing the problem of air pollution caused by motor vehicles.

2.10.1.1. The structure of the framework

The structure of the framework (based on the DPISR Framework) consists of six basic sequential compounds as follows:

2.10.1.1.1. Driving force indicators

The driving force indicators of the framework include the socio-economic and institutional factors which have contributed to the occurrence of the problem of air pollution caused by vehicles, in order to provide information and data about

Driver forces (D)

Socio-economic and institutional factors
affecting air pollution caused by motor vehicles

Management factors

Social factors

Legal & institutional factors

Economic factors

Pressure(P)

Emissions

CO, VOC, NMVOC, NO_x, NO, NO_2, PM:
PM_{10}, $PM_{exhaust}$.

Emissions inventory

Meteorological-related Parameters

Fuel-related Parameters

Vehicle-related Parameters

COPERT 4 Software

Air quality standards

State (S)

Air pollution

Impacts (I)

Economic Effects

Environmental Effects

Health Effects

Responds(R)

Alternatives for air pollution Reduction

Management Strategy of Air pollution Caused by Motor Vehicles

Legislations improvement

Public transport development

Institutional Supporting

Public Awareness raising

Vehicle Technology

Fuel Technology

Traffic Management improvement

Figure 2.2 A conceptual framework for air pollution caused by vehicles each factor and determine its contribution to the occurrence and increasing severity of the problem. The driving force indicators stage of the framework can provide detailed explanations of the data and information about each of these indicators, which have been divided into four main categories of socio-economic, and institutional affecting factors, including economic, social, legislation and institutions and management factors.

The framework divides these factors into four main categories: economic factors, social factors, legal and institutional factors, and management factors, as follows:

2.10.1.1.2. Economic factors

This section considers the affecting factors from an economic perspective, which have contributed to the presence of the problem of air pollution from cars. It includes;

i. The growth of the economy in the study area, which has led to an increase in per capita income.

ii. Facilities and loans granted by the government to the residents. This has affected the citizens' ability to buy new cars and has also led to an increase in the number of fleet vehicles in the city.

iii. The increase in the number of private cars due to the availability of cheap imported vehicles, which come without restrictions or tax, which has therefore led to an increase in the trade in both old and new motor vehicles.

iv. The absence of a public transport system, meaning that private cars are needed to travel around the city.

v. The provision of support for fuel prices due to the economic growth of the government and increase in people's incomes, which has led to a failure to impose a tax on fuel, keeping fuel prices lower and therefore increasing the amount of fuel consumed by cars.

vi. The absence of public transport, meaning that private cars are needed to travel around the city.

vii. The provision of support for fuel prices due to the economic growth of the government and increase in people's incomes, which has led to a failure to impose a tax on fuel, keeping fuel prices lower and therefore increasing the amount of fuel consumed by cars. All of these economic factors have contributed to the problem of air pollution from cars.

2.10.1.1.3. Legislative and institutional factors

The legislative and institutional factors in this theoretical framework are concerned with the status of the relevant national environmental legislation in terms of air pollution from cars and related issues, and the extent to which this legislation is sufficient and has the necessary force to control the legal aspect of this problem. These legislative and institutional factors also address the roles that should be played by the concerned institutions in pursuing the problem of air pollution, including reviewing the availability of human capacity and administrative and financial support for these institutions so that they can investigate the problem and find the required solutions for it. This section also investigates whether these institutions have taken some of the necessary measures in the past to address the problem in order to identify the positive and negative contributions of these institutions to this issue.

2.10.1.1.4. Social factors

This section of the framework deals with the social factors and will investigate the possibility of social factors affecting the occurrence of the problem of air pollution from cars in the study area. This section reviews and verifies the population growth rates and the level of public awareness of air pollution caused by vehicles in order to show to what extent that these factors can be considered to have contributed to the occurrence of the problem.

2.10.1.1.5. Management factors

This section of the framework deals with management as one of the factors that may contribute to the occurrence of air pollution caused by vehicles in the study area. These management factors include the management of traffic and the regulation of congestion on the road network, as well as issues relating to regulatory actions to develop a fleet of public transport vehicles. Therefore, this section of the framework will describe these factors to determine the extent to which they contribute to the problem of air pollution caused by vehicles in the study area.

2.10.1.1.6. Pressure indicators

The second compound of the framework involves the air pollutants emitted by motor vehicles which could be measured by calculating the annual quantities of these emissions. For this purpose, a vehicular emissions inventory for the period 2005-2010 in the study area was compiled by applying the COPERT 4 software program. Local familiarized models for estimating vehicle emissions were unavailable, and the COPERT software is widely used; moreover, most of the data required to apply COPERT 4 could be provided, combined with estimates of some data which were unavailable (see Chapter 5).

The pressure indicators include the emissions of CO, VOCs, NMVOCS, NOx, NO, NO2, PM 2.5, PM10, PM exhaust, CO2 and SO2.

2.10.1.1.7. State indicators

This compound concerns the change in the state of air pollution as a result of the pressure caused by vehicular emissions, which leads to a change in the state of the air quality, where such emissions could affect the natural compounds of atmospheric air and sol lead to a change in the state of air quality in the city. These state indicators must be considered an important issue that needs more attention and further investigation to define the actual extent of the air pollution caused by vehicles through the compression of the new state of the air quality with the air quality standard or reference year of emissions to establish the extent to which the state of air quality has changed as a result of the pollutants emitted by motor vehicles.

2.10.1.1.8. Impact indicators

The impact indicators include the health, environment and economic effects which may occur as a result of changes in the air quality state due to the presence of vehicular emissions in the atmosphere. The health effects include many diseases which can be caused by the exposure to air pollution, such as cancer, respiratory diseases, genetic mutation, blood toxicity and others. The environmental effects include climate change, ecosystems and landscape damage, while the economic effects include the impact on tourism, reduced crop production, damage to historical monuments, as well as the funds needed to treat the health effects and improve the damaged ecosystem.

2.10.1.1.9. Response indicators

These indicators are related to the available options. These responses may be made by the government, institutions and local authorities to address the problem. The options are many and varied, including the legal aspects, which include the development of laws and creation of standards for pollutants from cars and other aspects with regard to the support of the concerned institutions, including the development of the existing institutions through the provision of equipment required to control pollution. This includes improving and developing the capabilities of the technical staff of these institutions and some of the other available options regarding the transfer towards the use of alternative clean technologies that contribute towards reducing the volume of pollution in both vehicles and fuel technology. The available options also include developing the infrastructure of the public transport sector and the mechanisms for managing congestion on the road network.

The response indicators include creating a management strategy to reduce the problem of air pollution from motor vehicles which could involve all of the necessary instruments, including economic, legal and institutional ones, and everything necessary to develop such a strategy. Such a strategy should include the evaluation of the current status of air quality and the development of an action plan, based on that evaluation, to be implemented in different phases and within a specific timeframe, involving all of the concerned sectors, supported by the financial funds needed for its implementation. The solution to the problem of air pollution generated by vehicles will require cooperation and coordination between all of the relevant sectors to create and implement a complete strategy for addressing the problem. No such strategies have been proposed in previous years. The institutions have strongly supported the need to develop, with government support, a strategy for managing air pollution from cars in order to prevent the aggravation of this problem and the damage it causes.

The strategy must include relevant topics related to the air pollution caused by vehicles, such as the development of related environmental laws, systems for adopting vehicle technology and fuel technology, training and rehabilitation, the development of the public transport sector and the raising of public awareness about traffic air pollution. The creation of a strategy for the management of air pollutants from road transport requires an action plan for the short-, medium- and long-term, and this plan must have a definite timeframe.

2.10.2. Sources of data needed for the implementation of the framework

This framework requires the provision of a lot of data and information in order to be applicable for assessing the statues of air pollution caused by vehicles in Tripoli. For this purpose, the developed framework will employ all of the primary and secondary data gathered and the results which may be obtained from the analyses of all of these gathered data and information (Figure 2.3).

Developed Framework for

Air pollution caused by vehicles in Tripoli

Data required for the framework

Analysed secondary data

Analysed primary data

Literature Review

Archives and Documentation

Traditional Library

Vehicular Emissions

Interview Data

Questionnaire Data

Observation Data

Figure 2.3 Sources of data required for the developed framework

2.10.3. Difficulties encountered in applying the framework in the study area

The application of the different phases of the proposed framework to air pollution caused by vehicles in Tripoli could face some difficulties which can be described as follows:

i. Currently, as in previous years, there exist no guidelines or specific frameworks that have been applied in the study area, which has made it impossible to apply such guidelines or frameworks, develop them for application in this study, or compare this framework with any other previous frameworks to identify the degree of success of this framework.

ii. There is a lack of data needed to apply certain stages of the framework, particularly for evaluating the effects of air pollutants emitted by cars, as there are shortcomings in the health surveys and environmental assessments of these effects, with no data being available about the types and extent of these effects. Access to this information needs continual surveys and experts in the assessment of the different effects of air pollution. In the absence of such necessary data, the application of this phase of the framework remains incomplete.

iii. The absence of standards and criteria on air quality, the lack of an air quality monitoring system, and the shortage of continuous measurements for air quality levels were obstacles to defining the actual extent of the air pollution caused by vehicles.

2.10.4. Overcoming the difficulties facing the application of the framework in the study area

The framework suggests some recommendations which should be considered for the successful completion of the application of the framework on air pollution caused by vehicles. These recommendations areas follow:

i. Data and information on air quality in the city must be available, including surveys of the effects of air pollution from cars. Standards and criteria should be created for air pollutants emitted from cars, in order for this framework to be applied in a comprehensive manner; this requires field surveys and studies.

ii. The mechanisms already existing in EGA for reducing the air pollution caused by vehicles and all related issues should be reconsidered to ensure that all of the necessary data and information for the application of this framework are provided. This requires training and rehabilitation for technical staff who are responsible for dealing with air quality issues.

iii. The establishment of an air quality monitoring system and the creation of standards and criteria for air pollutants will provide the kind of data needed for the application of this framework and lead to more details of all phases of the framework.

iv. The sources of information and data used to apply the framework must have credibility, trust and stability, and no contradictions or discrepancies, in order to ensure that the framework can be applied properly. This requires the provision of a documented and comprehensive database of all of the information required for the application of this framework.

v. This framework can be generalized and applied to other cities in the country in cases where the required data are available, and the government is urged to support any attempts to develop this framework by providing the necessary support for researchers and relevant institutions.

2.10.5. Uniqueness of the framework

The proposed framework is unique in the field of assessing the air pollution caused by vehicles. The justifications can be identified as follows:

i. The framework is not repeated or cloned from another framework.

ii. The framework has never been proposed and developed by institutions or people.

iii. The framework has been modified and developed to be commensurate with the air pollution from cars in the study area.

iv. The framework has been developed to have wide acclaim and be applicable in many countries in the field of assessing the various Environmental problems, which makes it more credible and provides an understanding of its components and the possibility of its application.

v. This framework has never been applied to assess air pollution from cars in the study area or at the national, regional and international levels.

vi. The framework offers a new understanding to conclude the relationship between the different affected factors on air pollution emitted from cars, which will help in terms of environmental studies and other related issues.

2.10.6. The benefits of the framework

There are many benefits that might ensue as a result of using this framework, which covers many relevant matters, as there exist many institutions and authorities, as well as independent people, that will have an advantage from using this framework in their work, where the framework has included many of the issues that correlate directly or indirectly with the issue of air pollution from cars, the framework ensures the coverage of economic, social, health, and legislative aspects related to air pollution from cars in the study area. The framework also addressed the solutions available to solve the problem; therefore, this framework could provide wide benefits for many individuals and institutions in the study area, as well as, other cities with similar conditions to the study area.

The most important benefits of the application of this framework are that it can access a large amount of information and data on the economic aspects related to the problem of air pollution from cars, including a knowledge of the economic returns resulting from the trade and import of cars and the income from this for both government and individuals who work in the field of the import and trade of vehicles. The economic aspects also include providing data on the size of the economic losses caused by air pollution from cars where such information and data would be useful in enabling the decision-makers to adapt this information to develop an effective plan and policy for addressing the problem based on accurate data and information provided by the application of this developed framework.

The benefits of a framework involving the research sector and those interested in studies of air quality and air pollution are that the framework provides a lot of data and information as well as clear mechanisms for dealing with all of the issues related to the problem, as it presents data on the amount of air pollutants emitted by cars, which can be used by researchers to make comparisons with air emissions from other sources. The framework offers the ability to open up new horizons in the field of the analysis of air pollution from cars, which can be generalized and applied to the other cities in the country and this would create a database on air pollution from cars at the national level, not only in the study area. The framework provides another benefit, suggesting software for making an inventory of the air pollutants emitted by cars, so researchers might consider using such software to make inventories of the air pollutants emitted by cars in other cities and countries as well.

In general, the application of this framework offers many benefits, which could be utilized for many relevant sectors including the environment, transport, communications, planning, education, scientific research, health and traffic sectors, in addition to the multiple aspects related to air pollution from cars which can be discerned through the application of the framework on air pollution caused by vehicles in Tripoli. The benefits will contribute to the increased knowledge and awareness of the problem, which involves people, institutions and decision-makers

2.11. Chapter Summary

This chapter has presented an overview of the air pollution caused by vehicles and the factors that have contributed to an increase in this problem. The chapter also identified different kinds of vehicular pollutants, the effects of vehicular emissions, the actions taken by governments to reduce the problem as well as the available options and instruments for developing strategies for addressing air pollution. It then presented the proposed conceptual framework.

The increase in the extent of damage to health and the environment from vehicle pollutants is directly related to the increase in the size of the private vehicle fleet, fuel consumption and the lack of provision of a public transport infrastructure. Some cities could be suffering more than others because of their economic conditions.

The levels of air pollution in many urban areas in developing countries exceed the required standards and, therefore, such pollutions still represent an environmental problem that has health, environmental and social effects in cities. Consequently, many governments take action and measures to reduce the negative effects of pollutants emitted from vehicles.

This chapter introduced a developed framework based on the DPSIR Analytical Framework, which will be applied to air pollution caused cars in Tripoli city. All of the information provided in this chapter will be considered in the selection of the research methodology presented in the next chapter.

Chapter Three

Research Methodology

3.1. Introduction

The aim of this study is to investigate the air pollution resulting from the use of land transport and identification of the main affecting factors that have played a significant role in the existence of this environmental problem. This chapter provides an overview of the research methodology and the practical approach adopted to achieve the research objectives.

The selection of the research methodology is affected by the researcher's theoretical perspective as well as his attitude towards the direction of the logic which will be used to collect the data (the inductive or deductive approach) (Gray, 2009). The researcher must also explain the reasons used for selecting the research methodology adopted (Crotty, 1998). According to Creswell (1998), qualitative research is a process of investigation that aims to promote understanding, based on the distinctive tradition methodology, for the purpose of addressing a social or humanisation problem. The choice of methodology to be used in the research depends on the research questions (Aashish and Bruce, 2009).

The research processes began by selecting the research problem, clarifying the aims and objectives of the research and developing the research questions. The second step is to conduct a review of previous studies followed by deciding the methodology and approaches which would be effective in answering the research questions. The required data have been collected using multiple qualitative methods, including semi-structured interviews with experts and decision-makers in the concerned institutions, complemented by questionnaires and direct observation. Secondary data were collected from previous studies, scientific reports, and records and documents available from the relevant authorities. The third stage of the research process was the analysis of the data collected from primary and secondary sources while the last stage involved developing and utilising the theoretical framework to test various scenarios for the evaluation of air pollution caused by vehicles in the study area figure (3.1).

Research Methods

Data Collection

Literature Review

Interview

Archival &documentation

Secondary Data

Primary Data

Questionnaire

Traditional Library

Observation

N

Quantitative Analysis

Data Analyses

Emissions Inventory

Qualitative Analysis

Application of the Framework

Figure 3.1 Research Methods

3.2. Research paradigm

3.2.1. Theoretical approach

According to Crotty (1998), the researcher must distinguish between research in terms of the epistemological and theoretical perspectives and should avoid using both the objectivist and constructionist approaches at the same time. The opinions, views and ideas that have been collected from the residents of the study area, experts and staff of the local institutions on the problem of air pollution from cars have been gathered by following series of research constructivism-interpretivism/phenomenology. The choice of this approach and the rationale for selecting it will be discussed in detail in this section.

Epistemology attempts to answer two kinds of question: How do we identify the world? And what is the association between the Inquirer and what is researched (Maynard, 1999).

The Constructionism approach gives the researcher the opportunity to create a strong collaboration with the respondents, so that the respondents can relate their stories in more detail and, through these stories, describe their views of the reality in which they live. This equips the researcher with a greater understanding of the concerns of the participants (Miller and Crabtree, 1999: Guba and Lincoln, 1989).

In this study, the researcher selected constructionism as the epistemology as it allowed him to interact with the respondents who live in the study area, as well as experts and local authority staff, in order to understand and build a reality from the different points of view of those concerned. The participants in the study were selected in order to reach a better understanding of the phenomenon of air pollution from cars. The approach used was a grounded theory approaches which involved a constant comparative method of analysis and interpretation.

3.2.2. Theoretical perspective

Research philosophies include positivism, post-positivism and interpretivism. The distinction between these philosophies does not mean that one is a better than the others, but each can do the same things differently and better (Sandelowski et al. 2007). The interpretive research attempts to understand a phenomenon through studying it in its natural context, based on the views of the respondents, without a control or any premeditated theories or any attempt to generalize(Walsham,1995:Wynekoop and Russo (1997).The phenomenological approach concentrates on exploring how people confront the phenomenon to which they are exposed in the sense of how they consider it and also seek to describe the phenomenon and what it means to them (Patton, 2002).

In this study, the researcher travelled to the study area to meet the residents, experts and local responsible authorities to engage with them and collect in-depth data and information regarding the air pollution caused by vehicles in Tripoli and to understand their views and behaviour regarding the air pollution problem in the study area. According to the collected data and information, the researcher developed interpretations to serve the main purpose of the research which was to investigate the size of the problem and determine the affecting factors that have contributed to its occurrence, as well as provide recommendations to help the concerned institutions to reduce the air pollution caused by vehicles.

3.3. Research approach

Yin (2003) defined the research design as a logical sequence for connecting the experimental data to the initial research questions. Yin (1984) divides case studies into three categories: exploratory, descriptive and explanatory case studies. The descriptive case study is a mere description of the situation, while an exploratory case study goes further than simply describing the situation. This type of exploratory case study is used in many cases to provide a basis for an expanded and thorough analysis in the later stages (Kyburz, 2004).

The choice of the kind of case study depends on the overall objectives of the study, i.e. whether its aim is to describe the phenomenon, explore the issues or compare cases (Yin, 2003). Also, there is a distinction between an individual case study, a comprehensive case study and multiple case studies (Baxter and Jack, 2008).

This research is an exploratory case study as the researcher seeks to explore the problem of air pollution from vehicles in Tripoli city and investigate the affected factors that have led to the occurrence and increase of this problem, as well as review the measures taken by the responsible authorities to address the problem and minimize its effects on health, the environment and the economy.

3.3.1. Inductive and deductive approaches

There are two different types of research approach. The first approach is the deductive approach, whereby a researcher develops a theory or hypothesis and designs a research strategy in order to test it. The second approach is the inductive approach, in which the researcher begins collecting data in order to try to develop a theory (Sandelowski et al. 2007). The inductive approach begins when a researcher starts his study from the observations and development of research hypotheses, while the deductive approach begins when a researcher already has hypotheses and wants to test them against existing observations (Curry et al.,2009).

Lauri and Kyngas (2005) stated that the inductive approach is applicable if the researcher does not have prior knowledge about the phenomenon or if this knowledge is fragmented. The researcher should explain the kind of approach selected for his research and provide a justification for using it. It is possible to use both the inductive and deductive approaches in the same research, which will provide many advantages (Sandelowski et al. 2007).

3.3.1.1. Inductive and deductive approaches for this research

This research aims to investigate the phenomenon of air pollution caused by land transport in Tripoli city where the author will identify the affecting factors that have led to the problem and also investigate the technical, administrative and legal measures, which have been taken by the responsible authorities to reduce the traffic air pollution in the city. For this purpose, both the deductive and inductive approaches were applied. The research is partly deductive, as it proceeds from a base of prior theory, which guided the instrument development and observations. However, in order to obtain a better understanding of this phenomenon, the researcher has collected data and information about this issue through in depth-interviews, questionnaires and direct observations, and sought to analyse and interpret all of these data in order to provide a better understanding of this phenomenon and develop his own conceptual framework. He will then make proposals and recommendations to assist the decision-makers and civil society in the study area to address the problem. In this sense, an inductive approach was also applied. This combined approach is consistent with the suggestion of Sandelowski et al. (2007), mentioned above.

3.3.2. Qualitative and qualitative approaches

Amaratunga et al. (2002) categorized research into two kinds; qualitative research and quantitative research. The main difference between the qualitative and quantitative approaches is in terms of the procedure rather than the quality (Gharietal. 1995).

Curry et al. (2009) pointed out that qualitative and quantitative researches are differentiated according to the following:

i. Quantitative research is concerned with values and prepares for events such as estimating prevalence and frequency, while qualitative research seeks to describe the complex processes and the breadth of the events or phenomena studied.

ii. Quantitative research seeks to test hypotheses statistically, while qualitative research seeks to create and produce hypotheses about a phenomenon and its precursors, as well as their consequences

iii. Quantitative research may be carried out in randomized or non-random trials and involves the production of digital data being generated through the processes and tools associated with the groups in response, while qualitative research occurs in the natural environment rather than as an experiment, and generates text-based data through discussions and observations. Amaratunga et al. (2002) suggest that, in deciding whether to use a qualitative or quantitative approach, it is necessary to explore these alternatives in more depth.

3.3.2.1. Qualitative approach

Qualitative research is a form of scientific research, which includes many disciplines, topics and methodologies. Multiple qualitative methods can be used to understand the complex processes of any social phenomenon, from the perspective of the participants involved in the study (Curry et al.2009). Qualitative research in general is inductive rather than deductive in nature, which indicates that it produces theory through interpretations of the evidence (Foss, 2002). Qualitative research strategies include the initial foundations of the theory, ethnography, case study and phenomenology. The choice of a qualified design is determined in accordance with the basic objective of the study (Curry et al. 2009).

3.3.2.2. Quantitative approach

Quantitative research not only uses numerical measurements, but also follows the methods of the Natural Sciences for the purpose of establishing knowledge. In general, the use of quantitative research refers to the use of the deductive approach, which tests assumptions derived from theory (Foss, 2002).

Amaratunga et al. (2002) point out that, in an academic environment, where resources are limited, quantitative research is practical in terms of permitting large-scale data collection and analysis with reasonable cost and effort, as well as being able to provide statistical evidence. Qualitative research is more useful in terms of measuring variables.

3.3.2.3. Mixed methods

In some situations, a combination of quantitative and qualitative methods, called mixed methods, strengthens the research. Among the benefits of combining the two approaches (qualitative and quantitative) is the fact that, in larger studies, they can achieve multiple goals, including supporting the results and creating more comprehensive data. The quantitative and qualitative components can be implemented synchronously or in sequential form (Curry et al. 2009). Mixed methods can take advantage of the strengths of each approach and thus compensate for any weaknesses, and also contribute towards providing answers to more detailed and comprehensive questions (Denscombe, 2008).

3.3.3. The research approach adopted for this research

According to the aims and objectives of this study, the researcher adopted a mixed methods approach for obtain deep answers to the research questions.

The choice of this approach was based on the nature of the phenomena involved.

Quantitative methods enable basic data to be collected on various aspects of the research problem, such as vehicle numbers and the volume of emissions, while qualitative methods enable the exploration of the attitudes, perceptions and values of the participants.

3.4. Research strategy

3.4.1. Case study strategy

Kyburz (2004) has stated that the case studies seek to explain the phenomenon. Baxter and Jack (2008) suggested that the case study is a great opportunity to acquire the best, most comprehensive knowledge on the issue. It allows the researcher to collect data for the study through a variety of diverse sources.

Case studies offer several advantages, including the fact that they collect data in the context in which it is used. The second feature is that the differences in terms of methodologies allow the use of quantitative and qualitative analyses of the data. It assists the interpretation of the complexities occurring in real life situations, which cannot be achieved through empirical research or surveys (Zaidah, 2007). In a case study, the research contributes to an explanation of the phenomena which are being studied with a gradual variation in terms of theoretical interpretation and deep analysis of the phenomenon (Kyburz, 2004).

3.4.1.1. Case selection for this research

According to the aims, objectives and research questions of this study, the researcher decided that an exploratory single case study method was the most appropriate choice. This study focuses on the answers to ‘how’ and ‘why’ questions (see chapter one) and explores the contextual conditions which the researcher thinks have a close connection with the phenomenon of air pollution. The use of a case study method will lead to the advantages claimed for this method by Yin (1994), which include examining the significance of a phenomenon in its natural context, the production of theory relevant to the phenomenon through concepts that are under the control of the researcher as a result of the practice, gaining a comprehensive understanding of the relatively complex conditions making up the entire phenomenon, and exploratory investigation, where the variables are not yet known.

3.5. Data collection methods

3.5.1. Overview

According to the research objectives, three methods were selected to collect the primary data needed for the study. The first method is the personal in-depth interviews with experts and responsible people, who were carefully selected based on the experience and knowledge of the researcher in this field, as well as knowledge of the institutions concerned to follow-up air pollution and traffic issues (see Chapter One).The researcher conducted interviews with ten people from three institutions related to the research topic; more details about these interviews will be presented in the following sections of this chapter.

The second data collection method was a questionnaire which was prepared in accordance with the objectives and research questions. Two hundred copies of the questionnaire were distributed to a random sample of the city's residents, and 158 people responded. The questionnaire will be discussed in more detail in this chapter.

Research Methodology

Methods

Research strategy

Research approach

Research paradigm

Theoretical Approach

Data Collection

Case Study

Qualitative &Quantitative

Epistemology

Constructionism

Data analysis

Inductive & deductive

Interpretivism

Exploratory & Explanatory

Phenomenology

Figure 3.2 Research Methodology

The third method for collecting primary data was direct observations, whereby the researcher employed his experience and knowledge to record and document the observations made during the personal interviews and field visits to the study area. The secondary data needed for the study were collected from previous studies related to the research, scientific reports and publications of local institutions interested in the subject matter and from archive libraries, newspapers and Internet networks.

3.5.2. Interview

Cohen et al. (2000) have suggested that there are four common types of interview, as follows:

i. Open- ended unstructured interviews

The conversation is informal and, usually, the interview begins with general questions related to the topic, followed by specific questions to obtain information. In this type of interview, it is unnecessary to cover the same topics with all the participants, but a variety of topics are discussed. The interview is dynamically flexible, which can lead to open access to data which was not anticipated.

ii. Closed structured interviews

The closed structured interview can discuss and cover the same topics with all participants. The features of structured interviews include the fact that the data obtained will be more focused in comparison with those obtained through unstructured interviews. The data collected in closed structured interview are largely consistent with the objectives of the research.

iii. Semi-structured interviews

Semi-structured interviews combine mixed approach of open-ended unstructured interviews and closed structured interviews.

iv. Focus group interviews

This type of interview involves a group of people discussing an issue. These interviews are characterized by gathering information from a group of participants at the same time.

3.5.2.1. Advantages of in-depth interviews

This type of interview is particularly useful when there is a need to ensure that openness exists in the relationship between researchers and participants in the research, or in cases where there is confidentiality and the need to alleviate the fear of negative consequences that may result from the provision of certain data. Interviews are usually conducted either face to face or over the phone or via the Internet (Curry et al. 2009). In-depth interviews often include qualitative data. Therefore, this is also called qualitative or unstructured interviewing. This kind of interview is useful for extracting deep information in order to achieve a comprehensive understanding of the interviewees' perspectives and attitudes regarding the topic. The questions for in-depth interviews are open-ended and, if necessary, can be amended to obtain more information (Berry, 1999).

3.5.2.2.The interview process in this research

i. Development of an interview schedule

The interview questions were derived from several sources, including the research questions, previous studies on air quality and air pollution from motor vehicles, and were open questions. The type of interview selected was an open-ended unstructured interview.

The main questions for each authority were based on its task, taking into account the research questions and objectives.

The main aims of these interviews are to obtain the information and data as well as gather the interviewees 'opinions concerning the topic of the study, so the questions focused on gathering data and information about the following points:

- The status of air quality in the study area.

- The source of air pollution in the study area.

- The air pollution caused by motor vehicles

-The affecting factors that have led to the air pollution problem caused by motor vehicles.

-The effects of air pollution caused by motor vehicles in the study area.

-The national environmental legislation and relevant regulations.

- The roles of the responsible institutions.

- The actions taken to address the traffic air pollution problem in the study area.

- The options available to reduce air pollution caused by motor vehicles in the city of Tripoli

- The instruments required to create a strategy for solving the problem,

ii. Pilot study

Pre-testing

The researcher conducted two pilot studies to test the interviews and ensure that the contents of the questions covered all of the required issues related to the topic of air pollution caused by vehicles.

Pre-test one

In this stage, contact was made with three technical staff who work in EGA and individual experts interested in the field of environment management, who were requested to provide their comments and views about the contents and form of the interview questions, such as whether the questions covered all of the issues related to air pollution caused by vehicles, and whether they were clear, flexible and easy to understand and answer. They provided several comments which were taken into account.

Pre-test two

At this stage, two interviews were carried out. The first was a semi-structured interview with a member of EGA staff, who was in the United Kingdom at the time. The interview lasted approximately one hour. The second was with members of the Association of Taxi Drivers. This interview was conducted during the fieldwork visit and lasted 40 minutes.

iii. Interview sample

The interviews in this study involved managers and technical staff of the concerned authorities, involving ten people in total.

- Environment general authority (EGA)

Specific questions were posed to four EGA staff. The interviewees were considered as one group, divided into three job types; two were department managers, one an engineer and the other an administrator.

- General Department of Traffic and Licensing (GTL).

Specific questions were presented to three GTL officers. The interviewees were considered as one group, divided into three job types; one department manager, one traffic police officer and one traffic police-administrative.

- Association of taxi drivers (ATD)

Specific questions were presented to the three ATD members. The interviewees were considered as one group, divided into two job types; one taxi association manager and two taxi drivers.

iv. Administration procedures in the main study

At the beginning of each interview, the researcher introduced himself, the nature of the research, and his organization, provided a brief explanation about his research objectives, then clarified the purpose of the interview in order to simplify the subject, develop a rapport with the respondent and also create a suitable climate for the interview. This helped in achieve more interaction and thus obtain more information.

The interviews were carried out during the period 22 July to 22 September 2010.The interviews lasted50-60 minutes each, on average. Permission was obtained to record all of the interviews.

A digital recorder including photos and video recording were used. Personal notes were also taken by hand, where the author documented the observations. The respondents reviewed their answers and approved them, and the interviews ended with an expression of appreciation for the participants 'cooperation who were informed that they would be able to see the results of this study once it is finished. The outcomes of the interviews will be discussed in detail in chapter seven.

3.5.3. The Questionnaire

Questionnaires can be divided into two types: mail- and self-administered questionnaires. The mail-questionnaire is sent by post to the selected respondents, and should be accompanied by a letter stating the objectives of the questionnaire that requests the participants to complete it by a specific deadline. The second type of questionnaire is distributed by the researcher to the participants directly or with the help of volunteers and staff of the study. Again, there will be a cover letter attached to it, describing the objectives (Burcu, 2000).

3.5.3.1. Types of questionnaire

Yin (2003) classified the different types of questionnaires into three groups including:

i. Structured questionnaires: based mostly on closed questions; **ii. Unstructured questionnaires:** based on open questions which allow the respondents freedom to respond to questions in their own words; iii. **Semi-structured questionnaires: based on** a mixed approach between **structured questionnaires** and **unstructured questionnaires.**

3.5.3.2. The questionnaire process employed in this research

i. Development of the instrument

The researcher developed a standardized questionnaire whereby answers are selected from options provided. The researcher prepared specific questions based on the research questions and objectives. The questionnaire was translated into Arabic with the aid of a professional person in order to be understood by the respondents, whose first language is Arabic. The questions involved structured questions (closed questions) and a Likert scale was applied, with five possible responses provided for each statement - 5 (strongly agree), 4 (agree), 3 (neutral), 2 (strongly disagree) and 1 (disagree). Other questions offered only two possible responses: yes or no.

The questionnaire was divided into sections as follows:

- Demographic information: age, gender and educational level

- Air quality status in Tripoli.

. Air pollution caused by vehicles in Tripoli.

- Affecting factors that have led to the problem of traffic air pollution.

- Effects of traffic air pollution.

- The role of the concerned institutions.

- The relevant legislation and regulations.

- Reliance on private vehicles for travelling.

- Available options for reducing traffic air pollution in Tripoli.

- Management strategy needed to resolve the problem.

ii. Pilot study for the questionnaire

A pilot study was conducted to test the questionnaire format, sequence and concept.

The researcher conducted two pilot studies to test the questionnaire and determine whether any topics relevant to the subject of the study were missing.

Pre-test one

To investigate the viability of the questionnaire, contact was made with three people who had used questionnaires to collect data on environmental issues. They were requested to provide their observations and remarks about the form and contents of the questionnaire questions and whether they were understandable, flexible and easy to answer. A few comments were provided regarding some of the questions which needed to be simplified in order to be understood by the respondents. These were taken into account and the questions modified in the final version of the questionnaire.

Pre-test two

in this phase, five copies of the questionnaire with a feedback form were distributed to people who live in the study area, selected at random. They were asked to provide any comments on the kinds of questions asked, as well as their style, format, clarity and difficultly to understand. The respondents supplied some comments about the contents of the questions as well as their opinions about the categories of the questions. All of the feedback gathered from the respondents was taken into account and the questionnaire revised, with a few modifications to the sections.

iii. Population and Sample

According to Barreiro et al. (2001),three fundamental points need to be taken into consideration when we need to obtain a sample from the population, including the method used in the selection of the target elements of the study population, the sample size and the degree of reliability of the conclusions which we can obtain. There are three types of sampling: purposive sampling, no rule of sampling and probability sampling. Probability samples include random, Stratified, Cluster and systematic sampling:

1. Random Sampling

Selecting samples randomly is the most common of all kinds of strategies for sampling, where each the person has an equal opportunity to be one of the sample (Charles and Fen, 2007).

2. Simple Random Sampling is characterized by methods that are easy and affordable and there is an equal chance for all of members of society to b chosen. This condition is called non-zero chance, giving them the opportunity to be representative sample of the community significantly.

3. Stratified random sampling is used when the population is divided into layers of natural and there exists a desire to represent all of these layers in the sample.

4. Systematic random sample: this sample is created by dividing the units of society into regular layers and choosing a simple random sample or systematic sample of all of them (Kothari, 2004).

iv. Sample Selection employed in this research

This research adopted a probability sampling strategy using a simple random sampling selection technique. Two hundred individuals were selected from the population of the study. The samples were residents of the city, of different ages (18 years and over), gender and educational levels, who were selected from different locations in the study area, including streets and roads, shops and supermarkets, fuel stations, Tripoli University, three secondary schools in the city, the EGA, the Ministry of Transportation, the Ministry of Planning, and the General Association of taxis and traffic police .

The researcher sought to obtain a representative sample of the population of the study area, and so set the following selection criteria:

- Age of respondent: at least 18 years old.

- Residents of the study area.

The draft questionnaire consists of several sections; the first is designed to collect personal information from the respondents. In the second section, it was decided to use a five-point Likert scale ranging from Excellent to Very poor, to describe the air quality in Tripoli, while the third section employed two-point Likert scale, including yes or no, to consider the causes of air pollution in Tripoli. Sections three to seven employed a Five point Likert scale, ranging from strongly agree to strongly disagree, to identify the affecting factors related to air pollution caused by vehicles as well as the effects of vehicular air pollutants. In addition, the actions taken to address the problem, the achievement of reliance on private vehicles, the available options for reducing the problem and the management strategy required to address the problem. In section eight, a two-point Likert scale was employed, including yes and no options, in order to clarify the ownership of private vehicle. Following the pilot study, and according to the respondents' opinions, some modifications and amendments were made to make the questionnaire is easier, clearer and more comprehensible.

v. Administration procedures in the main study

Enclosed in the questionnaire package was a covering letter that briefly explained the aim of the study. Two hundred copies of the questionnaire were distributed to people in different locations within the study area. The target groups were residents of the city of different ages, gender and educational levels, selected at random. The questionnaire form is shown in Appendix (1)

Two hundred questionnaires were distributed in the different places and locations in the study area, and the completed questionnaires were collected via selected collection points in certain institutions, shops, supermarkets and fuel stations, directly by the researcher. The response rate was 79%.

The questionnaire made a special contribution towards achieving the objectives of this study. The information and data obtained from it were very useful and helped the researcher with the further data collection approaches which were used in this research.

3.5.4. Direct observation

According to Randolph (2007), in direct observation, the researcher observes the behaviour of people without making any changes to the natural situation. People's behaviour can be observed directly in several ways, as follows:

i. A free form, in which the researcher is located at the centre of the actions of the participants and takes notes on this behaviour.

ii. By pre-specifying the behaviour of interest and counting the number of times that an instance of such behaviour takes place, at specified intervals, or classifying the events that took place.

In this study, the researcher utilized his scientific background in atmospheric science and experience in the field of environmental management to make observations during the field work in the study area and also visited the authorities and institutes to obtain copies of reports and documents. These observations were useful as evidence to compare with the information and data gathered via the interviews and questionnaire. The direct observation was performed during the fieldwork period (July-September 2010).

The researcher visited various locations in the study area, including the EGA, to gather information about its technical potential, parameters and laboratory in terms of controlling air quality and checked the potential of the traffic police in the field of traffic management on the road networks in the city. The researcher recorded cases of pollution emitted by vehicles as well as cases of traffic congestion. In addition, he obtained some relevant reports from the authorities concerned.

3.5.5. Documented data

The researcher gathered secondary data from archives and documents of concerned ministries, including the Ministry of Transportation, Planning, and authorities such as the Environment General Authority, the General Authority of Information and the Traffic Police Department. He also reviewed previous technical papers, the relevant literature and reports of regional and international organizations, as well as websites.

3.6. Data analysis

3.6.1. Qualitative (Interviews)

According to Gray (2009), there are two main approaches regarding the analysis of qualitative data: content analysis and grounded theory. The first method focuses on identifying specific categories, as well as criteria for the selection of these categories before starting the analysis. In the second approach (grounded theory), no specific criteria are set in advance, so that all of the measures and themes emerge the process of gathering and analysing the data. The process of analysing the data using the technique of grounded theory takes place in three stages. The first stage is the open encoding, in which data are gathered into units. The second phase is axial coding, in which the relationships between the categories are identified, and the third phase is selective coding, in which the main categories are combined to produce theory (Strauss and Corbin, 1998). In most cases, researchers collect large amounts of data about the phenomenon being studied and often use various computer programs to facilitate the processing and analysis of qualitative data through several phases, beginning with the encoding, organization, searching, and retrieval of data, because of the large volume of data generated. The software provides the characteristics and competencies needed to organize and retrieve the data (Curry et al. 2009).

In this research, the data obtained from various sources were analysed using the content analysis. The analysis process began with transcribing then encoding. The next step involved the classification of the data into different groups, then analysing the similarities and differences between the groups and categories, which were classified, in order to discover the real meaning of the data.

The primary data obtained from the interviews were transferred into a Microsoft excel program for the purpose of sorting and grouping and then analysed manually.

3.6.1.1. Validity, reliability and triangulation

i. Validity

There are two main issues in the process of validity; namely, whether the tools used for the measurements are accurate and whether they actually measure what the researcher actually wanted to measure (Winter, 2000). According to Ritchie and Lewis (2003), the concept of validity is based basically on two issues: internal validity(which ensures that the researcher can achieve his research objectives) and external validity, which is concerned with the extent to which the results of the research can be generalized to the wider population.

In this research, several measures and procedures were undertaken to ensure the validity, including pursuing a number of methods to investigate the research problem from different angles in order to strengthen the validity of the results. The selection of the case study strategy helped to include all of the issues related to the topic of the study as well as to increase the probability that the results may be generalized. In addition, the aims and objectives of the research were the main source of the questions that were asked during the interviews and via the questionnaires, which covered all aspects of the research topic. The data were recorded, documented and analysed with a very high degree of accuracy. The interview data were checked by re-listening to the recorded interviews to ensure the accuracy of the data. Also, secondary data were used to evaluate the validity and accuracy of the data obtained from the interviews and questionnaires. In addition, the researcher confirmed the accuracy of the data by comparing it with the data gathered through direct observations documented by the researcher.

ii. Reliability

Ritchie and Lewis (2003) defined reliability as meaning, if these studies were to be repeated using the same research methods, to what extent the same final results would be obtained. Marshall and Rusman (1999) and Seal et al.(1999) noted that there can be no absolute reliability for the results of qualitative studies, because the results obtained express or reflect the facts during the time period in which the data were collected, which often change over time.

For the purpose of enhancing the reliability of this research, a number of actions were taken. Recordings were made of all interviews to provide more evidence and thus avoid any bias that could occur if the researcher were merely attempting to remember the conversation.

In addition, the questions were formulated clearly and, in case of confusion or misunderstanding of the question, the researcher re-explained the question so that the respondents might understand it more easily. The researcher provided full opportunities and freedom to the respondents to express their opinions and beliefs without making any interventions, comments or suggestions regarding their answers, which could create bias.

Naturally, the circumstances surrounding this study could be different if it were repeated, but this study attempts to contribute with others to an understanding of every aspect of this research, as well as to clarify the procedures followed in this study, which may increase the likelihood that it will support others who might wish to repeat the study. This study provides information and disaggregated data on the aims and objectives of the research and also outlines clearly how the research was conducted through offering a detailed account of the procedures and methods employed. It presents a rationale for the strategies adopted in the study and the methods of data collection and analysis.

iii. Triangulation

Triangulation means that the researcher uses a variety of methods to gather and interpret data about the phenomenon of the study and research in order to obtain an accurate representation of reality (Foss, 2002). The use of multiple methods helped with the data triangulation and, at the same time, provided an efficient way to overcome the majority of the weaknesses of each method used (Gray, 2009). Triangulation reduces the risk of both personal and methodological biases. It also increases the possibility that the findings of the study may be generalized. The data were collected from various angles and via different methods (Decrop, 1999).

In this research, data and methodological triangulation were applied while collecting the data from different sources, including: semi-structured interviews, questionnaires and direct observation.

3.6.2. Quantitative (questionnaire)

The data collected through the questionnaires were analysed using the statistical package for social sciences (SPSS 18). This software is probably the most widely used statistical software package for quantitative analyses in the social sciences.

3.7. Inventory of vehicular emissions for the period 2005-2010.

Due to the lack of data about the air pollutants emitted by vehicles in the study area, it was required to determine the extent of the problem of air pollution caused by vehicles in the city and to apply the proposed framework for this study, so an inventory of the vehicular emissions in the study area for the period 2005-2010 was calculated. This was done by inputting data gathered from different sources into COPERT.4 software. This inventory of vehicular emissions in the study area included: Carbon monoxide (CO), Carbon Dioxide ($C02$), Nitrogen Oxides (NOx), Nitrogen monoxide (NO), Nitrogen dioxide ($N02$), particulate matters (PM exhaust, $PM25$ and $PM10$), volatile organic compounds (VOCs), non-methane volatile organic compounds (NMVOCs), and sulphur dioxide ($S02$). More details and a discussion about this inventory will be presented in Chapter Five of the study.

3.8. Adaption of the Framework methodological for this research

There are two types of survey that may be employed in this kind of research - exploratory and explanatory. The exploratory case study goes further than simply describing the situation. This type of exploratory case study is used in many cases to provide a basis for an expanded and thorough analysis during the later stages (Kyburz, 2004). A decision must be taken to select which kind of approach should be used, and the kind of methodology that will be most effective in collecting the data required and ensuring that the research objectives can be achieved.

For this research study, the aims and objectives presented in Chapter one described the study as concerned with investigating and exploring the factors that affect air pollution caused by motor vehicles in Tripoli and finding ways to improve those factors. It is therefore an exploratory research study with the principal aim of developing a framework for the evaluation of air pollution caused by motor vehicles in Tripoli, the resulting increased success of which will lead to improvements in the status of the air quality in that city. More details on the framework and its application to test various scenarios for the evaluation of air pollution caused by motor vehicles in Tripoli will be presented in Chapter nine.

3.9. Chapter Summary

This chapter has presented a discussion of the methodology used in the study, including the theoretical approach, research approach, design, and data collection methods. In order to achieve the research aims and objectives, a mixed methods approach was adopted.

An exploratory single case study method was chosen, focusing on answering “how "and “why” questions. Three methods were employed to collect the primary data needed for the study; semi-structured interviews, a questionnaire and direct observation documentation. The data were transcribed, encoded and classified into groups, then subjected to critical analysis. The aim of the research will be achieved by investigating the air pollution caused by vehicles and determining the affecting factors that have contributed to the existence of the problem, which can contribute towards providing recommendations to address the problem of air pollution caused by vehicles in Tripoli. The next chapter will present the observations made during the field visit to the study area and the concerned institutions during the period July-September 2010.

Chapter four

Field work observations

4.1. Introduction

This chapter presents the observations made during the field work visit to the study area, which took place in the period July-September 2010. The observations made included all issues relating to the topic of air pollution caused by vehicles in the city of Tripoli. The researcher lives in the study area and therefore has an extensive knowledge of the city, experiencing on a daily basis the problems related to the increasing number of vehicles and growing severity of the congestion on the roads. In addition, the researcher has over 19 years of experience of working in the Pollution Control Department of the General Authority for the Environment and so has gathered a lot of information regarding the data in this study area and the subject of air pollution from cars. Consequently, the author employed his knowledge and experience (see Chapter One) when making these observations, which will be presented in this chapter. In additions, these observations were considered in preparing the questions for the questionnaire and interviews and to provide further explanation of the status of air pollution caused by vehicles in the study area, to complement the information and data gathered through the personal interviews and questionnaires.

4.2. The pre-research investigation

Many issues related to the study of air pollution from cars in the study area were addressed in this study for the purpose of ensuring that these issues were related to the subject of the study, to verify the feasibility of studying these issues, and to help in choosing the appropriate methodology for this research, including identifying the methods employed to collect the data and information from various sources. The pilot field research represented the first opportunity to subject all of the issues related to the topic to test and scrutiny through the views of the participants in the study. The pilot study was conducted in a manner that was consistent with the purposes and objectives of the research. The primary purpose of this study is to understand how the air pollution from cars occurred in the study area, and which affecting factors contributed, directly or indirectly, to the occurrence and aggravation of this phenomenon as well as its effects. Therefore, the first target of the pilot research was to clarify the occurrence of the problem of air pollution from cars in Tripoli and consider the affecting factors as well as the effects that resulted from this, as well as the steps that must be followed to deal with the problem.

Two groups were selected for the pilot study: the Environment General Authority and the General Association of Taxi Drivers. These institutions were selected based on their involvement with the topic of the study and their roles in such issues.

Personal interviews were held with specialists and officials. The questions posed to the participants during the interviews were in accordance with the issues related to the topic, and included questions regarding the status of the air quality in the city, the main sources of air pollution, the contribution of road transport to air pollution in the study area as well as the affecting factors that contributed to the growing phenomenon of air pollution from cars. They also included questions related to the impacts resulting from exposure to air pollution from cars. The questions also inquired about the national laws and legislation on the subject of air pollution from cars, the roles of the institutions involved in monitoring and addressing the problem, the actions that have already been taken by the authorities to address the problem in previous years and the capability of these institutions to provide action plans and projects to reduce and address the problem in the coming years.

These interviews showed that there had been significant increase in the size of the vehicle fleet in Tripoli as well as the quantity of fuel consumed by car engines, while the infrastructure of the public transport sector was weak, consisting only of taxis and minibuses. The national environmental law in terms of air quality issues is insufficient, as there is no specific law on air quality. The interviews also indicated that the human resources required to address the problem were unavailable. The results of the interviews indicate that there is a phenomenon of traffic congestion on the road network in the city, and an inability among the concerned authorities to address air quality issues and conduct the necessary measurements of air pollutants emitted by these vehicles. In addition, a lack of equipment for measuring and analysing the air pollution caused by vehicles and also the lack of an air quality monitoring system in the city were indicted. The Interviews also suggested that there is no inspection of vehicles to test the technical efficiency of their engine as well as a lack of technical conditions that must be met by imported cars. Also, the tax on imported vehicles is low.

These assumptions raises the following points:

i. Many affecting factors played a role in the occurrence of the problem of air pollution from cars in the city and its aggravation.

ii. The roles and functions of the concerned institutions are an essential element of these issues.

iii. The status of the relevant national environment in terms of resolving the problem is a significant issue which must be considered.

All of these assumptions and their implications were taken into consideration for the purpose of adopting the appropriate methodology for the research, including the methods for collecting the required data for this study.

4.3. Pilot study results

The aim of the field visit to the study area was to verify the occurrence of the problem of air pollution from cars and investigate it. The visit involved several related sites in the city, including the road network, in order to identify the status of traffic congestion on the roads and investigate the system used for monitoring the air quality in the city. Also, visits were made to the concerned institutions, including the Environment General Authority, the Department of Traffic Administration and Licensing as well as the headquarters of the General Association of Taxi Drivers, in order to identify their roles on issues related to the topic of traffic air pollution, including their human and technical capabilities. Copies of relevant reports and documents were obtained during the visits.

The observations made during the fieldwork visit to the study area (July-September 2010) showed that there are many indicators of the occurrence of the phenomenon of air pollution from cars in the study area. The main affecting factors that led to this were the growth of the economy which has developed in Libya over the past few years where the gross national income per capita has developed from 7628 USA dollars in 2005 to 16750 USA dollars in 2009 (WB, 2009), where this increase in income led to an increase in the capacity of people to own their own vehicle. Moreover, popular markets in the trade of old cars were established, and the national banks provided loans for people to buy a new car, which also contributed to the increase in the number of private cars. The level of tax on imported vehicles was low and all of these economic factors have contributed to the increase in private car ownership and thus increased the size of the vehicle fleet in the city. The observations made through collecting information from people who work in the trade in new and used vehicles showed that the increase in income has led to trade activities in new and used vehicles in the city, where there are a lot of vehicle exhibitions that are devoted to the sale of new vehicles, and also the spread of agencies importing cars was observed, so the increase in the number of vehicles has led to increased activity regarding the repair and maintenance, plumbing and painting of vehicles, whereby hundreds of workshops for this purpose in the city have opened, all of which have been considered a positive effect for people who deal with the trade, maintenance and repair of motor vehicles. The excessive increase in the number of private fleet vehicles was based on the total increase in the number of fleet vehicles in the city, where the possession of private vehicles outweighed the growth of public transport. Private fleet vehicles in Tripoli represent 79.07% of the total number of fleet vehicles in Tripoli, which increased from 610 vehicles/1000 persons in 2005 to 839 vehicles/1000 persons in 2010 (DVR, 2010) and an increase in the amount of fuel consumed as well as the poor infrastructure of the public transport sector, weak national environmental legislation on air pollution control and the incapability of the concerned institutions to address the problem and reduce its impacts.

The observations made during the field work visit will be presented in this chapter of the study as follows:

4.4. General Description of the Study Area

The study area is the city of Tripoli, which is the capital of Libya, located in the north coastal zone of the country, and extends to 50 kilometres towards the southwest of the country (GAI, 2009). Tripoli city is the main centre of the Tripoli region which includes 12 sub-regions, including the city. The city of Tripoli is located at latitude 32.56 degrees north and longitude 13.10 degrees east (NCM, 2008).

4.4.1. Traffic congestion

During the field visit to the road network in the city, traffic congestion has been observed on most of the main roads, particularly at the entrances and exits to places such as hospitals and major shopping centres. It was noticed that there were many vehicles parked on the roadsides and that led to increases in the volume of traffic congestion and disruption to the traffic flow, due to the insufficient numbers of car parks. It was also observed that the facilities for managing traffic flow were unavailable, as traffic management relied on mechanical instruments and it was observed that the traffic management was done by the traffic police in the traffic areas and depended on traffic lights only.

The observation showed that the city of Tripoli suffers from traffic congestion on the road network which differs from one location to another, being greater in the city centre. The traffic congestion occurs during most periods of the day. The severity of the traffic congestion was due to the existence of a number of factors, such as the road conditions, the planning of the road network, insufficient parking for vehicles, the system of tax on the roads and parking in certain places, as well as the absence of any restriction on private vehicle entry to intensive areas, which led to an increase in traffic congestion, as shown in photographs 4.1 and 4.2 below.

Photograph4.1 Traffic congestion on a highway in Tripoli at 9.30am on 25/07/2010

Photograph 4.2 Traffic congestion in Tripoli city centre at 14.30pm on 15/08/2010)

4.4.2. Public awareness of air pollution issues

The level of public environmental awareness on the issue of air pollution from cars has received no attention from the government. It was noticed that many of the people who live in the study area have little knowledge about the law of environmental protection and its contents, including air quality issues. The city has no civil association in the field of environmental awareness, including the issue of air quality; also there is no scientific journal or newspaper that focuses on issues related to air pollution in the city. Most of the activities in the field of the public environment are organized by EGA, mainly during various environmental events, such as the National Day for the Environment and World Environmental Day. The activities were limited, so an awareness of the issue of air pollution from cars was almost completely absent, even among the decision-makers in different institutions, because environmental education and awareness are paid no attention by the government and civil institutions. According to information gathered from EGA, its activities in terms of public awareness were limited to the problem of air pollution, and involved only a few lectures presented to primary and secondary schools and specific events, while EGA issues a magazine named "The Environment", which is usually distributed every two months. It covers many topics related to environmental aspects, including the issue of air pollution from cars, but the coverage is very limited and rare compared to other environmental issues.

4.4.3. The road network conditions

The road network in Tripoli connects all areas of the city and the city is surrounded by a ring road which connects the city from east and west. This has had a significant impact on reducing traffic congestion on the road network in some areas of the city. Many of the roads in the city were subjected to development in previous years, but some roads in the city centre are still without development. Some could not be developed because of the presence of historic buildings and the desire to avoid losing such buildings or changing the character of their features. This means that the road network in the city centre has very limited potential for development. The paved roads in Tripoli region amount to 6696 km. The average density of the roads is around 0.03 km per square kilometre, but in Tripoli Sub (Tripoli city), it is more intense, with a density of 0.36 km per square kilometres (NAI, 2008).

The study area has a ring road (highway) with a length of 24km along the borders of the city from west to east. It was observed that most of the roads in the city were in good condition but subject to traffic congestion at all hours of the day, particularly at peak times of travelling to and from work and study.

4.5. The status of air quality in the study area

According to the observations made during the field work visit to the study area, it was noticed that there is no air quality monitoring system in the city. There are no fixed stations for continuing the measurement of vehicular emissions and therefore there was no possibility or ability for EGA to gather continuous data and information about the air quality status in the city, including vehicular emissions. This has led to the inability to assess and evaluate the status of air pollution caused by vehicles and the air quality level in the city. Also, EGA does not have the equipment to take samples of air pollution or carry out an analysis. The observation suggested that there is no ability for EGA to assess the actual status of the air quality in the city, as that would require the provision of information and data on emission concentrations which were unavailable due to a lack of equipment and instruments.

4.5.1. Main sources of air pollution in the city of Tripoli

The direct observations made during the site visit in the study area showed that:

i. Heavy industrial activities were established outside the city and there are some light industrial activities, including metal smelting and food processing.

ii. A large number of vehicle and severe traffic congestion on the road network was observed.

iii. Large quantities of domestic waste were disposed of in open areas in certain locations in the city.

iv. The power generation plant was built in the western part of the city. It depends on polluted fuel, which may affect the air quality in the city.

v. It was clear that there is massive use of cooling systems in both homes and offices. This was confirmed by people and the markets that sell air conditioning and cooling systems in the city.

According to the observation made, it was noticed that the main sources of air pollution in the study area were vehicles, industry activities and waste disposal.

4.5.2. The contribution of motor vehicles to air pollution in Tripoli

During the field visit to the study area, many observations were made. These observations have indicated that land transport is the main source of air pollution in the city; the observations also suggested that all cars rely on polluted fuel, including petrol and diesel fuel, which can emit many harmful pollutants. Vehicles are not fitted with electric catalysts, which absorb pollutants before they can be emitted to the atmosphere.

The status of traffic congestion on the roads was observed in most of the streets and main roads as well as the congestion of vehicles at filling stations, although these are widespread in all areas of the city. During the observations, three cases of air pollutants emitted from cars were recorded, whereby large amounts of thick white smoke were emitted from the car exhaust. The first case was observed on 25 / 7 / 2010 at 14:25pm on the highway and the same vehicle was observed on 26 / 7 / 2010 at 11:30pm in the Guorgei area. This shows that there is no commitment on the part of car owners that pollute the air to comply with the traffic law, which prevents cars that emit pollutants from the network road. Also, the presence of such a vehicle on two different days is evidence that the traffic police don't stop polluted vehicles as well as suggesting the widespread non-compliance with the environment and traffic laws which have to been issued to protect air quality. The third case occurred on 28 / 08 / 2010 at 12:10pm in the city centre (see Photographs 4.3-4.5) below.

VJF
F J O

Photograph 4.3 Private car emits air pollutants in Tripoli *(25 17 I* 2010 at 14:25pm on the highway)

Photograph 4.4 The same private car emits air pollutants in Tripoli (26/7 / 2010 in 11:30pm in the Guorgei area)

Photograph 4.5 Private car emits air pollutants in Tripoli (28/08/2010 at 12:10pm in the city centre)

The observations suggested that vehicles have significantly contributed to air pollution in the city of Tripoli through emitting large quantities of harmful pollutants. This was verified by the emissions inventory for the period 2005-2010, which will be presented in Chapter Five of this study.

4.6. Questions developed from field work

According to the observation gathered from the field work, which was explained and discussed above, the extent of the problem of air pollution caused by vehicles and the serious effects in the study area become clearer. This prompted some new questions that were required to obtain more information and data about the problem, as follows:

i. What are the main sources of air pollution in Tripoli? Andhow dovehicles contribute to the air pollution problem in the city?

ii. How can the affecting factors contribute to the air pollution caused by vehicles?

iii. What are the roles of EGA in terms of air quality issues including the air pollution caused by vehicles in the city of Tripoli?

iv. Are there potential technical, human and financial resources for a management strategy for air pollution caused by vehicles?

v. Are vehicles subject to technical inspections to measure the types and concentrations of the pollutants emitted?

vi. Why do people in Tripoli wish to have private vehicles? Andwhy do they rely on their private vehicles for travel?

vii. How would the growth of the private vehicle fleet be achieved?

The answers to the research question, combined with the above further questions, will be presented in the next two chapters.

4.7. Chapter Summary

This chapter has presented the observations completed during the field visit to Tripoli and the concerned institutions in the area during the period July-September 2010.

The chapter presented all of the direct observations, as well as photographs taken from the road network, which show the traffic congestion. It was shown that the vehicle fleet in Tripoli has increased, as has fuel consumption, including petrol and diesel fuel, and that the public transport sector services were very limited and include only taxis, vehicles and minibuses. All of the observations described in this chapter were employed to develop the questionnaire, which is analysed in chapter six. , however, the vehicle emissions data will be reported, in the next chapter.

Chapter Five

The inventory of vehicular emissions (2005-2010) in Tripoli, Libya

5.1. Introduction

This chapter discusses the vehicular emissions for the period 2005-2010 in the city of Tripoli. The inventory was made in this study by applying the COPERT.4 software in order to obtain data on the annual emissions of air pollutants emitted by vehicles. Such data were not previously available due to the lack of such an inventory in previous years.

First, the method of conducting the inventory, including the software used and sources of data, are explained. The results of the inventory and measures of concentration are reported and discussed. Finally, a comparison is made between Tripoli and Sheffield, UK, to place the Libyan results in perspective.

5.2. The emission inventory

In most developing countries, the routine assessment and reporting of emission estimates of sufficient quality is absent. Where estimates exist, these are often unreliable, contradictory and/or unrealistic. In the majority of developing countries, the ability to make reliable estimates is generally lacking and, without detailed reliable emissions inventories, it is difficult to develop strategic plans to combat air pollution and monitor the efficiency of these plans (Haq and Schwela, 2008). The situation of the study area concerning the inventory of the emissions is the same as that in most developing countries. Routine inventory and measurements of air pollutants were unavailable, as no inventory had been made for air pollutants, including vehicular pollutants in the whole country, including the study area.

A few studies on the estimation of vehicular emission inventories have been carried out internationally. The vehicular emission inventory in Spain from 1988 to 2010 was estimated using COPERT software. The analyses included the emissions of several local, global and fuel-related vehicular pollutants. Also, a road traffic emission inventory was estimated in Sardinia, Italy, by using COPERT, in which the emissions of several vehicular pollutants were calculated and the contribution of different vehicle categories to the emissions was evaluated. Other methods have been applied to estimating vehicular emissions inventories based on the emission factors derived from remote-sensing measurements and vehicular activity data obtained according to fuel consumption (Hao and Shaodong, 2007). Many studies have compared the available methodologies for calculating emission inventories. Among the four models that are widely used to calculate urban emission inventories (namely, HBEFA, DRIVE-MODEM,DGV and COPERT), it was found that the results were generally in good agreement (Reynolds and Broderick, 2000).

The vehicle emissions inventory in the study area for the period 2005-2010 was calculated to establish the scale of the problem of traffic air pollution in Tripoli. Such data, previously unavailable, were needed as evidence to confirm the increase or decrease in the quantity of vehicle emissions in the study area. The emissions inventory was also needed for applying the theoretical framework on air pollution caused by vehicles in the study area.

5.2.1. COPERT 4 Software for vehicle emissions inventory

COPERT is a software tool developed by the European Environment Agency (EEA), which is widely used to calculate emissions from road transport. The methodology is part of the EMEP/EEA air pollutant emission inventory guidebook and is consistent with the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines. COPERT4 is a Microsoft Windows software program which was developed as a European tool for the calculation of emissions caused by motor vehicles. The majority of vehicle emissions can be calculated using COPERT 4, including regulated emissions, such as CO, NOx, VOC, and PM, and unregulated emissions, including N20, NH3, S02 and NMVOC, as well as the calculation of the total fuel consumption by vehicle engines (Dimitrios et al. 2012). COPERT 4 is accepted in Europe countries and in many developing countries because of its specialization in vehicular emissions. COPERT4 calculates emissions based on data on vehicle numbers, fuel consumption and characteristics, the average temperatures in the region, road distribution and conditions (rural road, urban road, highway) and the average speeds of vehicles (Progiou and Ziomas, 2012).

5.2.2. Application of COPERT 4 for an emissions inventory in Tripoli city

The COPERT 4 software program, having been compared with other models developed in other nations, was selected for the calculation of the emission factors for pollutants emitted by motor vehicles in the study area, where local familiarized models for estimating vehicle emissions were unavailable. COPERT is widely used and most of the data required to apply COPERT 4 could be provided.

The distinctive situation in a developing country such as Libya poses challenges with regard to data compilation due to the heterogeneity of the sources of data; the obstacles encountered were different in each case. The Tripoli situation is not easily comparable with that in European countries and other developing countries. The main difficulties in this study were found to be related to recovering the required data for the selected period of the study. There was a lack of certain data, mostly due to the absence of surveys and measurements as well as documentation of the required data, such as emission factors, average vehicle speed and annual mileage.

The data required to apply the COPERT4 software include the following:

i. Fuel consumption types and quantities as well as the sulphur content.

ii. Meteorological data like the average temperature and the Reid vapour pressure (RVP)

iii. Driving condition data including average speeds and annual mileages.

iv. Emission regulation.

v. Vehicle fleet numbers and categorization.

vi. Data introduction and execution of COPERT4.

The sources of data employed in the study were as follows:

5.2.2.1. Fuel consumption and sulphur content

The types of fuel used in the road transportation in the study area were petrol and diesel. The total fuel consumption for the period 2005 up to August 2010 was obtained from the company that markets the fuel consumed in the city, which is called AL-Brega Company.

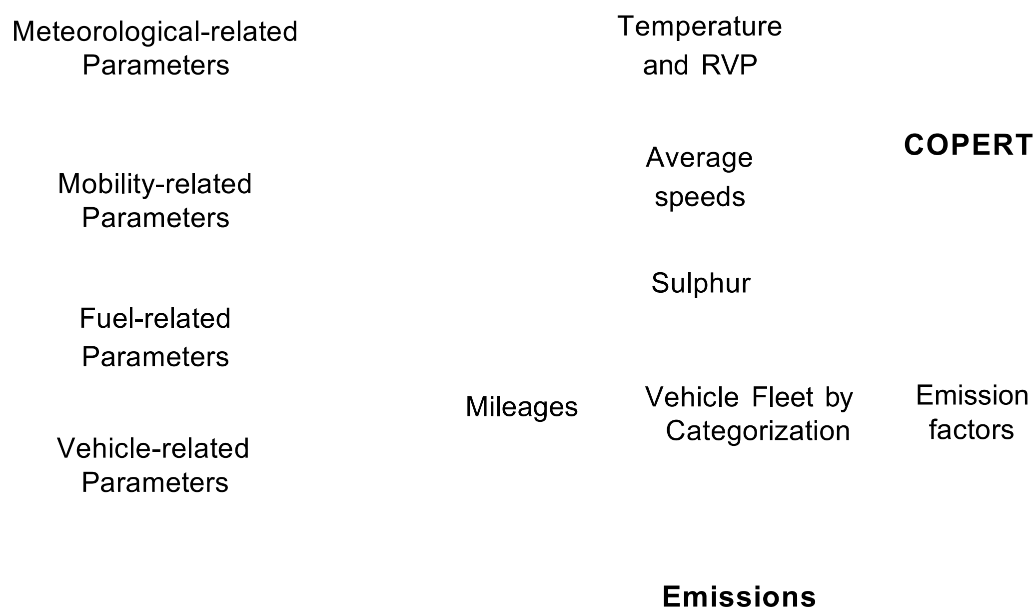


Figure 5.1 Synopsis of the procedures for estimating emissions using COPERT4

The quantities of fuel consumed for the rest of 2010, which information was missing from the statistics provided, were estimated based on the fuel consumption for the first eight months of 2010.

The sulphur content of each fuel type mainly affects the calculation of the emissions of SO_2.This information was gathered from the standards for sulphur content in petrol and diesel fuel adopted by the National Centre for Standards and criteria (Code: LNCSM 495.2007). The values of the sulphur content for petrol and diesel fuel are 0.015% and 0.08%, respectively.

5.2.2.2. Temperatures and RVP values

The monthly maximum and minimum temperatures were needed to calculate the cold emissions for each pollutant. The values of the monthly maximum and minimum temperature for each year for the period 2005-2010 were obtained directly from the national meteorological centre. The value of RVP required to calculate the evaporation loss of petrol was prescribed in the Libyan national fuel standards (Code: LNCSM 495.2007).

5.2.2.3. Regulation of emissions

No air emissions regulations are included at either the national and local level in national environment law No 15/ 2003. Due to the lack of such a regulation, the regulations in use are regional and international regulations, including European regulations (see Chapter 7), as the majority of the vehicles used in the study area use either Japanese or European technology. The regulations on vehicle emissions used in COPERT were European regulations, which are practically the same as those applied in Europe, and are pre-installed in the COPERT Software.

5.2.2.4. Vehicle fleet categories

The data on the fleet of vehicles in the study area for each year for the period from 2005 up to June 2010 were obtained directly from the administration of Vehicle Registration in the city, while the numbers of vehicles during the rest of 2010 were estimated based on the data up to June 2010. The categories and classification of the vehicle fleet in the study area proposed by DVR were based on the kinds of vehicles, such as private, taxi, and trucks. The data on the vehicle fleet obtained from the administration of vehicle registration in the city were categorized into four vehicle types: private vehicles, light-duty vehicles, heavy-duty vehicles and public taxis, as shown in Table 5.1 below.

Table 5.1 Type of vehicle fleet according to vehicle kind category (DVR. 2010)

Vehicles type	2005	2006	2007	2008	2009	2010
Private vehicle	485136	564182	650488	705025	752266	809815
Light-duty vehicle	97459	107044	116354	120599	124334	129407
Heavy-duty vehicle	22114	25921	29765	30518	30932	31774
Public taxi	30594	34880	40412	43740	47389	51657
Total	635303	732027	837019	899882	954921	1022653

5.2.2.5. Average vehicle speed

Vehicle speed data are used to calculate emission factors based on the emission factor-speed relationships available for different pollutants. Due to the lack of surveys and data on the average speed of all types of vehicles for previous years in the study area, the average vehicle speeds of all kinds of vehicles on different roads, including urban, rural and highways, for the period 2005-2010, used in the software, were obtained from the values shown in the regulations on the traffic network, as shown in Table 5.2 below.

Table 5.2 Limited speed for all types of vehicle in Libya (DVR, 2010).

Types of roads	Urban road Km/hr.	Rural road Km/hr.	Highway roads Km/hr.
Private vehicle	50	70	100
Light and heavy duty vehicle	40	60	80
Public Taxi.	30	50	65

5.2.2.6. Distances travelled by vehicle (mileages)

The annual average distance travelled by vehicles (mileage in km) was estimated according to a previous study conducted in Libya, which indicates that travelling a distance of 100 kilometres consumes 12 litres of fuel (Gabriel et al. 1992), and was based on the total quantities of fuel consumed by vehicles in the study area for the period 2005-2010, as shown in Chapter 2 (Section 2.3 and Table 2.2).

5.2.2.7. Emissions factors

The emission factors needed to complete the process of emissions calculation were calculated using COPERT4 software. This process requires the compilation of reliable data for the following specific parameters:

I. Fuel-related data like the sulphur content of petrol or diesel;

ii. Meteorological data such as the ambient temperature and Reid vapour pressure (RVP);

iii. Driving condition data like average speeds.

All of the required data were entered into the COPERT.4 software in order to gather the emission factors for each pollutant and so be in a position to calculate the total vehicular emissions for the period 2005-2010 in the study area.

5.2.3. Results of the emissions inventory

The inventory of emissions caused by vehicles in Tripoli, calculated for the period 2005-2010 using COPERT 4 software, included emissions of CO, VOCs, NMVOCs, NOx, NO, NO_2, $PM_{2.5}$, PM_{10}, PM exhaust, CO_2 and SO_2 (Table 5.3).

5.2.3.1. Emissions of CO

The total annual emissions of CO for the period 2005, 2006, 2007, 2008, 2009 and 2010 were 25,466.55, 29,251.31, 33,521.23, 36,038.25, 38,368.00 and 41,051.96 tons, respectively (Figure 5.2). The average annual rates of increase were 14.86%, 14.60%, 7.51%, 6.46% and 7.00% per year for the period 2006,2007,2008,2009,2010,respectively. The emissions of CO kilogram/capita/year in the study area for the period 2005, 2006, 2007, 2008, 2009 and 2010 were 24.46, 27.46, 30.77, 32.36, 33.72 and 35.33 kilogram/person/year, respectively

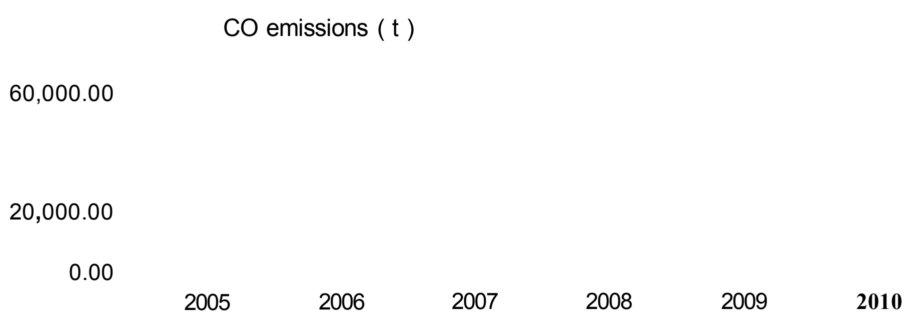


Figure 5.2 CO vehicular emissions in Tripoli 2005-2010

5.2.3.2. Emissions of VOC.

The total vehicular emissions of VOC per year for the period 2005-2010 were 2,314.35, 2,659.98, 3,046.91, 3,275.70, 3,485.17 and 3,728.66 tons(Figure 5.3) and the annual rates of increase were 14.93%, 14.55%, 7.51%, 6.39% and 6.99%, respectively. The emissions of VOC per kilogram per capita per year in the study area for the period 2005-2010 were 2.22, 2.50, 2.80, 2.94, 3.06 and 3.21 kilogram/person/year, respectively.

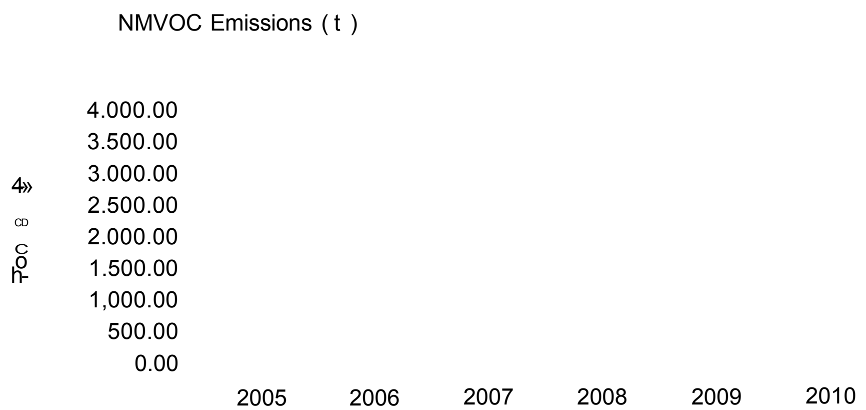


Figure 5.3 VOC vehicular emissions in Tripoli 2005-2010.

5.2.3.3. Emissions of NMVOC

The total annual emissions of NMVOC in 2005, 2006, 2007, 2008, 2009 and 2010 were 2,071.61, 2,380.83, 2,727.28, 2,932.07, 3,119.78 and 3,337.78 tons (Figure 5.4) and the annual rates of increase were 14.93%, 14.55%, 7.51%, 6.40% and 6.99%,2006, 2007, 2008, 2009, 2010 respectively. The emissions of NMVOC per kilogram per capita per year in the study area for the period 2005, 2006, 2007, 2008. 2009 and 2010 were 1.99, 2.23, 2.50, 2.63, 2.74 and 2.87 kilogram/person/year, respectively.

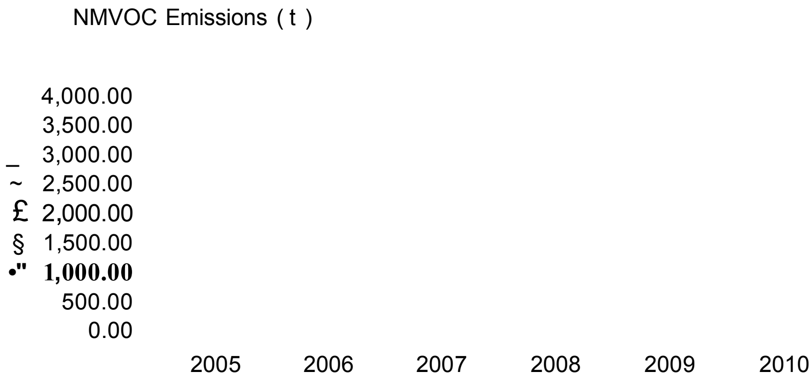


Figure 5.4 NMVOC vehicular emissions in Tripoli 2005-2010

5.2.3.4. Emissions of NOx

The annual total emissions of NOx in2005, 2006, 2007, 2008, 2009 and 2010 were 6,128.81, 7,066.88, 8,076.46, 8,683.06, 9,207.38 and 9,846.55 tons (Figure 5.5), and the annual rates of increase were 15.31%, 14.27%, 7.51%, 6.04% and 6.94%,2006, 2007, 2008, 2009, 2010 respectively. The emissions of NOx per kilogram per capita per year in the study area for the period 2005-2006. 2007, 2008, 2009 and 2010 were 5.89, 6.63, 7.41, 7.80, 8.09 and 8.47 kilogram/person/year, respectively.

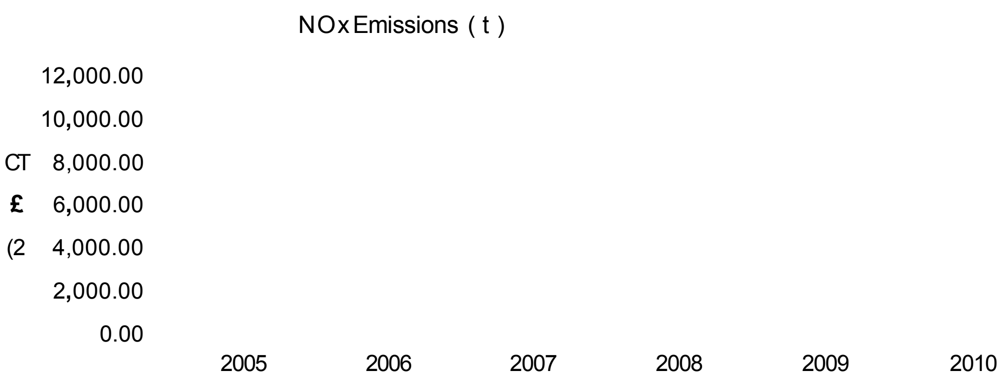


Figure 5.5 NOx vehicular emissions in Tripoli 2005-2010

5.2.3.5. Emissions NO

The total annual emissions of NO for the period2005-2010 were 5,853.83, 6,747.79, 7,713.41, 8,292.73, 8,796.23 and 9,407.23 tons(Figure 5.6), and the annual rates of increase were 15.27%, 14.31%, 7.51%, 6.07% and 6.95%, respectively. The emissions of NO per kilogram per capita per year in the study area for the period 2005-2010 were 5.62, 6.33, 7.08, 7.45, 7.73 and 8.10 kilogram/person/year, respectively.

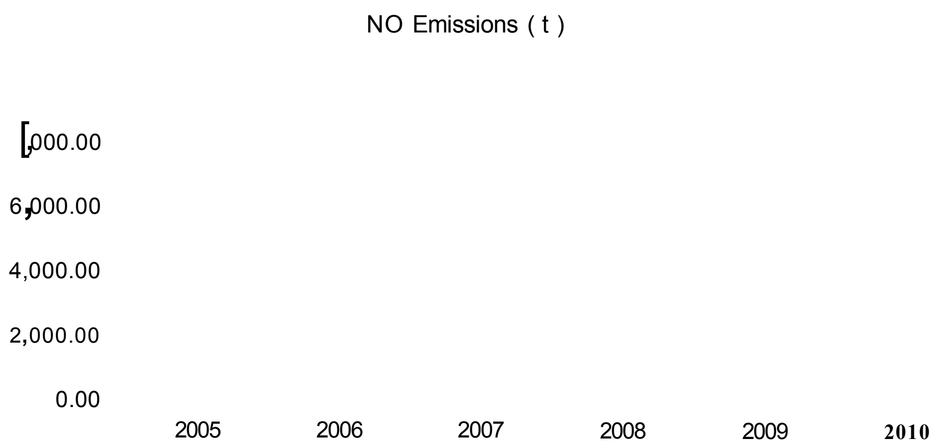


Figure 5.6 NO vehicular emissions in Tripoli 2005-2010

5.2.3.6. Emissions of N02

The total annual emissions of N02 for the period2005-2010 were 274.98, 319.10, 363.05, 390.33, 411.15 and 439.32 tons (Figure 5.7), and the annual rates of increase were 16.04%, 13.77%, 7.51%, 5.33% and 6.85%, respectively. The emissions of N02 per kilogram per capita per year in the study area for the period 2005-2010 were 0.26, 0.30, 0.33, 0.35, 0.36 and 0.38 kilogram/person/year, respectively.

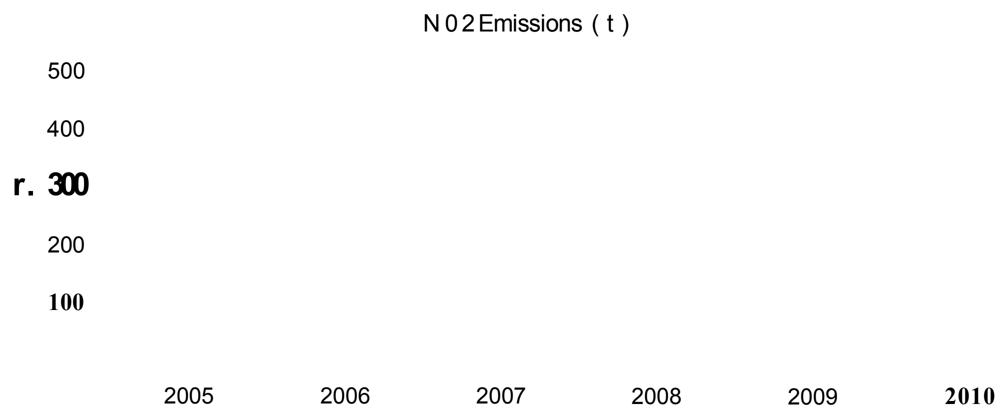


Figure 5.7 N02 vehicular emissions in Tripoli 2005-2010

5.2.3.7. Emissions of $PM_{2.5}$

The total annual emissions of $PM_{2.5}$ for the period2005-2010 were 228.15, 265.85, 301.59, 324.26, 340.06 and 363.17 tons (Figure 5.8), and the annual rates of increase were 16.52%, 13.44%, 7.52%, 4.87% and 6.80%, respectively. The emissions of $PM_{2.5}$ per kilogram per capita per year in the study area for the period 2005-2010 were 0.22, 0.25, 0.28, 0.29, 0.30 and 0.31 kilogram/person/year, respectively.

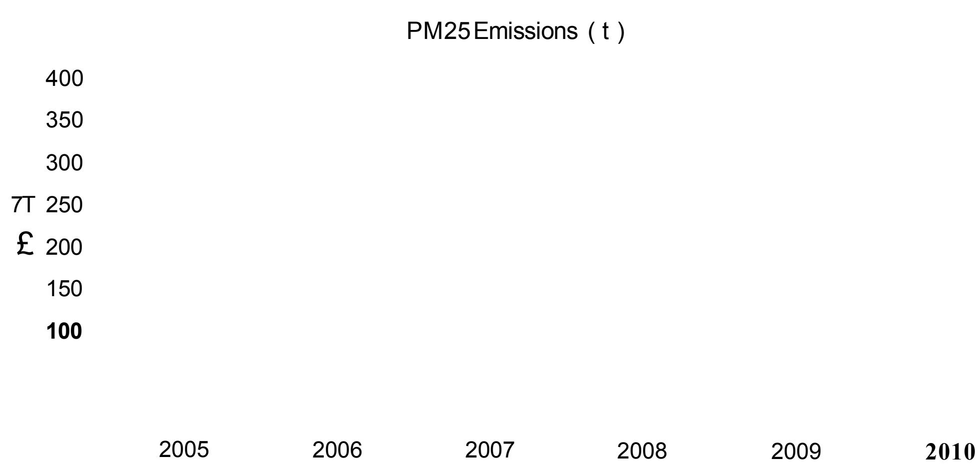


Figure 5.8 PM2.5 vehicular emissions in Tripoli 2005-2010

5.2.3.8. Emissions of PM10

The total annual emissions of PM_{10} in 2005-2010 were 335.51, 389.50, 443.02, 476.31, 501.50, and 535.84 tons respectively (Figure 5.9). The annual rate of increase is 16.09%, 13.47%, 7.51%, 5.29% and 6.85% for the years 2006, 2007, 2008, 2009, 2010 respectively. The emissions of PM_{10} per kilogram per capita per year in the study area for the period 2005-2010 were 0.32, 0.37, 0.41, 0.43, 0.44 and 0.46 per kilogram/person/year, respectively.

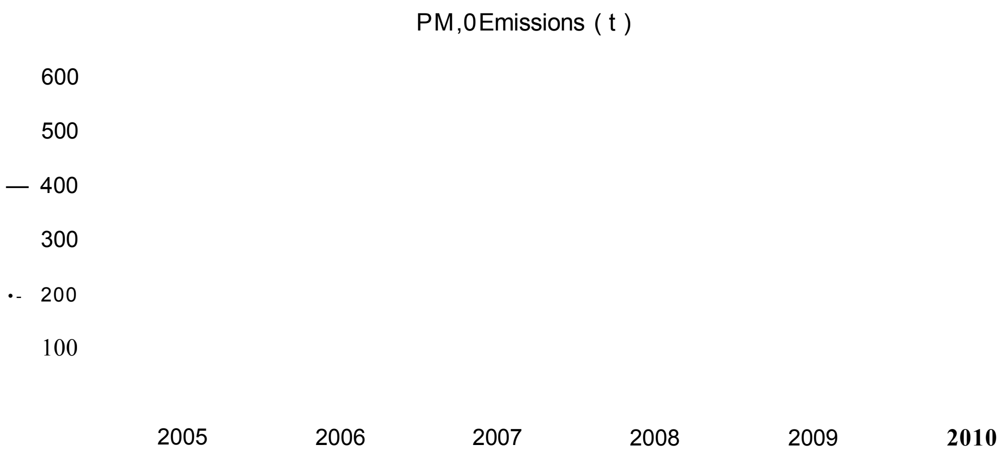


Figure 5.9 PM10 vehicular emissions in Tripoli 2005-2010.

5.2.3.9. Emissions of PM exhaust

The total annual emissions of PM exhaust in 2005-2010 were 90.88, 107.79, 120.77, 129.86, 133.62 and 142.35 tons (Figure 5.10), and the annual rates of increase were 18.61%, 12.04%, 7.53%, 2.90% and 6.53%, respectively. The emissions of PM exhaust per kilogram per capita per year in the study area for the period 2005-2010 were 0.087, 0.101, 0.111, 0.117, 0.117 and 0.123 per kilogram/person/year, respectively.

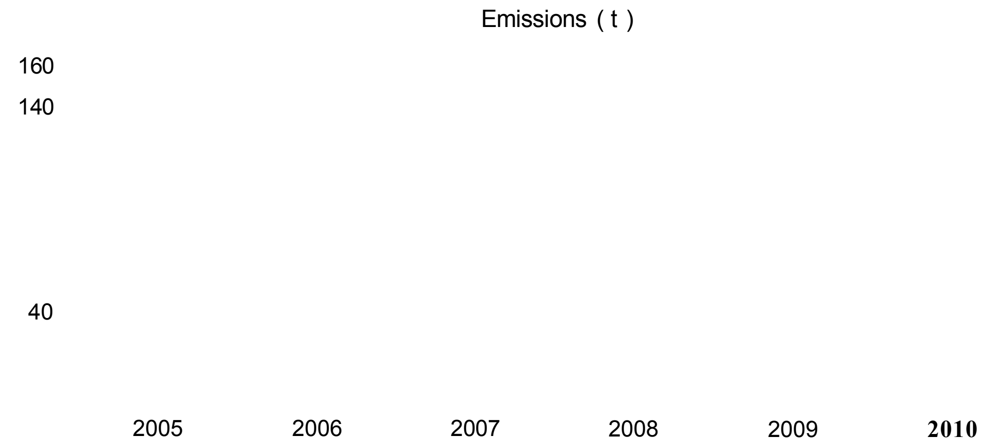


Figure 5.10 PM exhaust vehicular emissions in Tripoli 2005-2010

5.2.3.10. Emissions of CO_2

The total annual emissions of CO_2 for the period 2005-2010 were 2,090,530.00, 2,259,230.70, 2,518,337.80, 2,709,339.08, 2,968,024.17 and 3,284,687.43 tons (Figure 5.11), and the annual rates of increase were 8.07%, 11.47%, 7.58%, 9.55% and 10.67%, respectively. The CO_2 emissions per kilogram per capita per year in the study area for the period 2005-2010 were 2007.91, 2120.54, 2311.50, 2432.80, 2608.48 and 2826.84 kilogram/person/year, respectively.

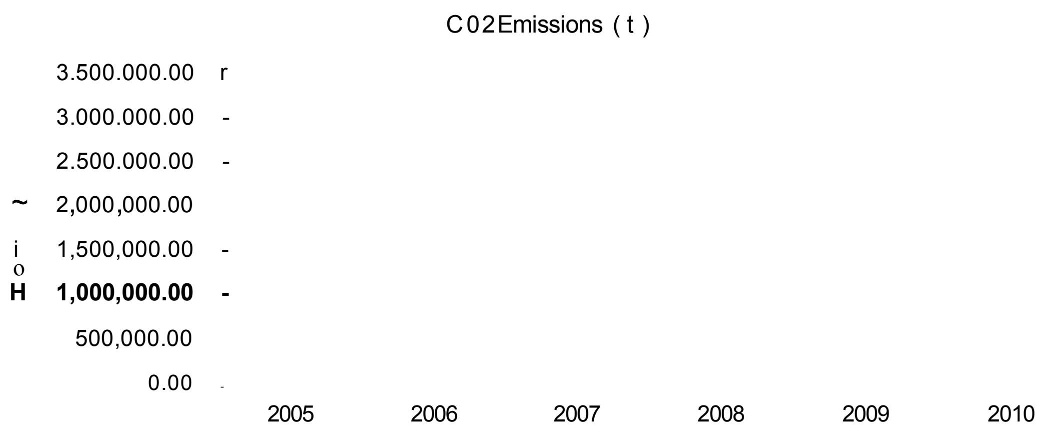


Figure 5.11 CO_2 vehicular emissions in Tripoli 2005-2010.

5.2.3.11. Emissions of S02

The total annual emissions of S02 for the period 2005-2010 were 162.62, 193.59, 230.05, 255.64, 339.05 and 449.85 tons (Figure 5.12), and the annual rates of increase were 19.04%, 18.38%, 11.12%, 32.63% and 32.68%, respectively. The $S0_2$ emissions per kilogram per capita per year in the study area for the period 2005-2010 were 0.156, 0.182, 0.211, 0.230, 0.298 and 0.387 kilogram/person/year, respectively.

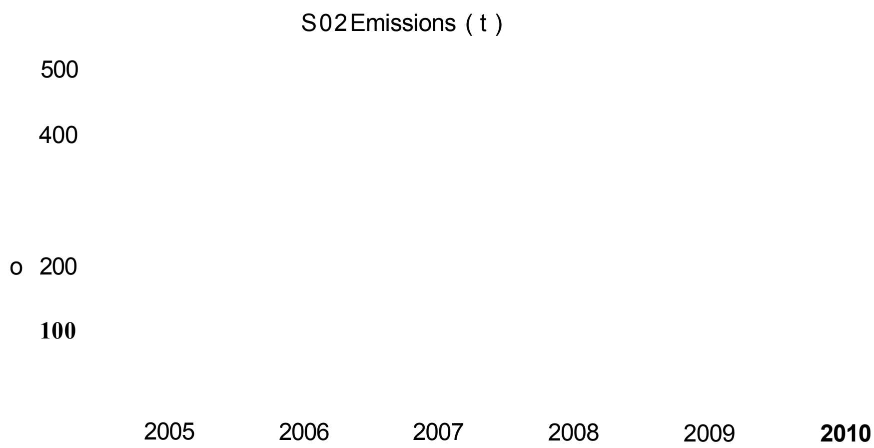


Figure 5.12 S02 vehicular emissions in Tripoli 2005-2010

Table 5.3 Total vehicular emissions in Tripoli for the period 2005-2010

Emission(Tons)		CO	VOC	[illegible]	NO_x	NO	NO_2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2005	Petrol	25,245.54	2,271.15	2,035.11	5,702.69	5,474.58	228.11	174.19	276.13	43.36	1,773,610.89	1.71
	Diesel	221.01	43.20	36.50	426.12	379.25	[illegible]	53.96	59.38	47.52	316,919.11	160.91
	Total	25,466.55	2,314.35	2,071.61	6,128.81	5,853.83	[illegible]	228.15	335.51	[illegible]	2,090,530.00	[illegible]
[illegible]	Petrol	28,981.46	[illegible]	2,336.27	6,546.59	6,284.73	[illegible]	199.96	316.99	49.77	1,881,522.64	1.82
	Diesel	269.85	52.75	44.56	520.29	463.06	57.23	65.89	72.51	58.02	377,708.13	191.77
	Total	29,251.31	2,659.98	2,380.83	7,066.88	6,747.79	319.10	265.85	389.50	107.79	2,259,230.77	193.59
2007	Petrol	33,224.92	2,988.99	2,678.35	7,505.14	7,204.94	300.21	229.24	363.41	57.06	2,069,170.27	2.00
	Diesel	296.31	57.92	48.93	571.31	508.47	62.84	72.35	79.62	63.71	449,167.53	228.05
	Total	33,521.23	3,046.91	2,727.28	[illegible]	7,713.41	363.05	301.59	443.02	120.77	2,518,337.80	230.05
[illegible]	Petrol	35,719.60	3,213.42	2,879.45	[illegible]	7,745.92	322.75	[illegible]	[illegible]	61.34	2,210,040.30	2.13
	Diesel	318.65	62.29	52.62	614.39	546.81	67.58	77.80	[illegible]	68.51	499,298.78	253.51
	Total	36,038.25	3,275.70	2,932.07	8,683.06	8,292.73	390.33	324.26	476.31	[illegible]	2,709,339.08	255.64
2009	Petrol	38,050.49	3,423.11	3,067.35	8,595.18	8,251.38	343.81	262.54	416.19	65.35	2,304,623.40	2.23
	Diesel	317.52	62.06	52.44	612.20	[illegible]	67.34	77.52	[illegible]	68.27	663,400.78	336.82
	Total	38,368.00	3,485.17	3,119.78	9,207.38	8,796.23	411.15	[illegible]	501.50	133.62	2,968,024.17	339.05
2010	Petrol	40,715.12	3,662.82	3,282.15	9,197.09	8,829.21	[illegible]	[illegible]	445.33	69.92	2,403,252.91	2.32
	Diesel	[illegible]	[illegible]	55.63	649.46	578.02	71.44	82.24	90 [illegible]	72.43	881,434.52	447.52
	Total	41,051.96	3,728.66	3,337.78	[illegible]	9,407.23	439.32	363.17	535.84	142.35	3,284,687.43	449.85

5.3. Measurement of the concentration of vehicular emissions in Tripoli city centre

5.3.1. Introduction

During the fieldwork trip in July-September 2010, which included a visit to the Environment General Authority, the researcher introduced and discussed the objectives of his research with the director general and manager of the laboratory department. They agreed that the mobile lab could be used for measuring the concentration of air pollutants emitted from vehicles in Tripoli city centre, so that the results of these measurements could be included within the content of this study. This was agreed because the researcher belongs to the EGA and this research will be employed as a basis for suggesting policies and action plans related to air quality issues. Accordingly, measurements of the air pollutants caused by motor vehicles were taken with the aid of the mobile lab during the period 21- 27 July 2010, in Tripoli city centre.

5.3.2. Description of the mobile laboratory used to measure air emissions in Tripoli city centre

The mobile lab used to measure the concentration of vehicular emissions in Tripoli city centre during the period 21-27July belongs to EGA and was imported in April 2010; it contains eight items of equipment that are used to measure and monitor 15 air pollutants.

The mobile lab contains certain units and devices needed for emissions measurements, which include (Photo 1):

i. A Monitoring Unit related to dust in the air (Fine Particles: PM10, PM2.5 and PM_1).

ii. Meteorological sensors

iii. The calibration unit "Calibration system CMK"

iv. Data logger device

utM'ur-

Photograph 5.1.The mobile lab used to measure the concentration of vehicular emissions in Tripoli city centre.

5.3.3. The results of the measurement of vehicular emissions concentration in Tripoli city centre.

The mobile laboratory was located close to the main square in the city centre and, following the required calibration of all of the devices, which was done by the technical staff of the laboratory department of EGA, the mobile lab was left for a week for the period 21-27 July / 2010.

Periodic measurements throughout the specified period were taken to measure the concentrations of vehicular pollutants in Tripoli city centre. The results were recorded and saved on the mobile lab's computer system.

The concentrations of $PM_{2.5}$ emissions were 27.5, 33.3, 21.0, 23.1, 15.9, 15.4 and 20.4 pg/m$_3$ for 21-27 July 2010,respectively (Figure 5.13).

Figure 5.13 PM2.5 concentration

The concentrations of NOx emissions were 74.6, 74.4, 48.3, 84.0, 56.2, 59.6 and 58.7 pg/m$_3$ for 21-27 July 2010 respectively (Figure 5.14).

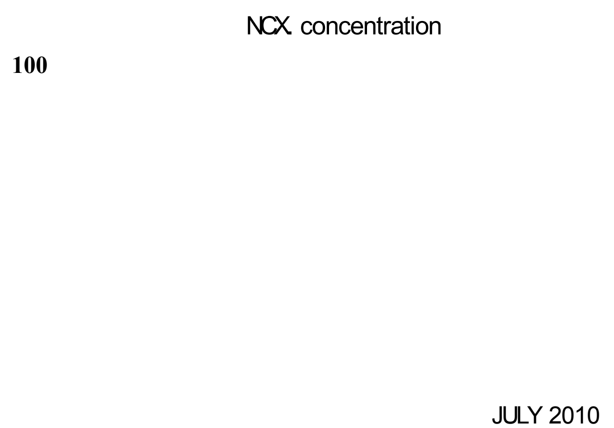


Figure 5.14 NO concentration.

The concentrations of $N0_2$ emissions were 44.4, 44.9, 32.3, 45.9, 30.3, 29.5 and 33.5 pg/m$_3$ for 21-27 July 2010 respectively (Figure 5.15).

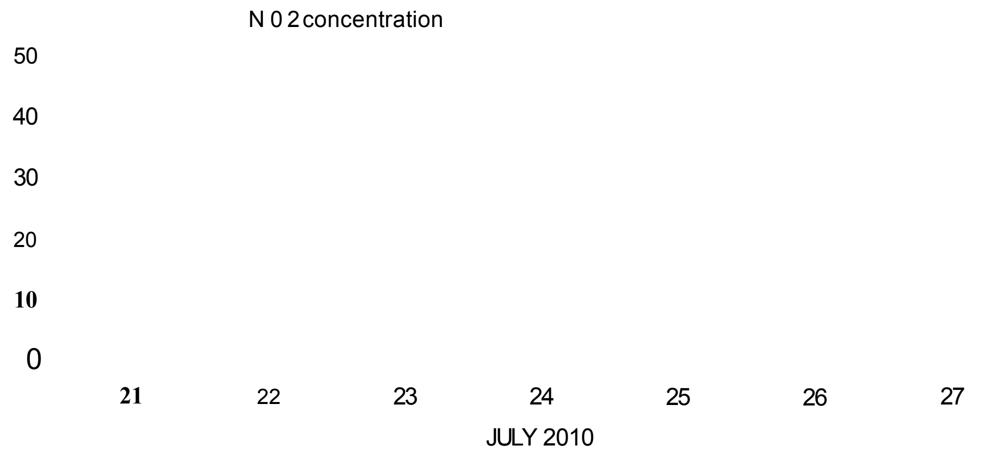


Figure 5.15 N 0 2 concentrations

The concentrations of NO emissions were 20.1, 19.6 , 10.6 , 25.2, 17.3, 20.0 and 16.9 (jg/m3 for 21-27 July 2010 respectively (Figure 5.16).

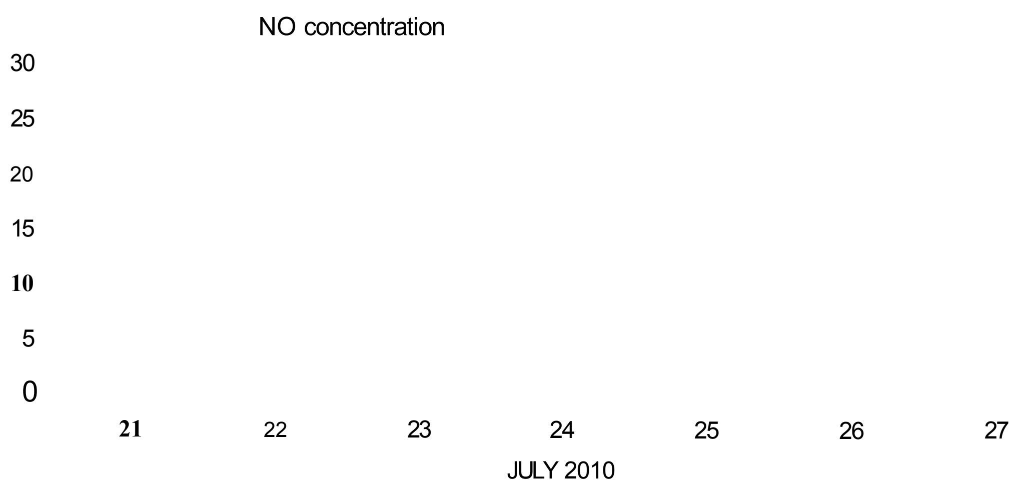


Figure 5.16 NO concentrations

The concentrations of CO emissions were 0.6, 0.6, 0.4, 0.6, 0.4, 0.4 and 0.3 mg/m3 for 21-27 July 2010,respectively (Figure 5.17).

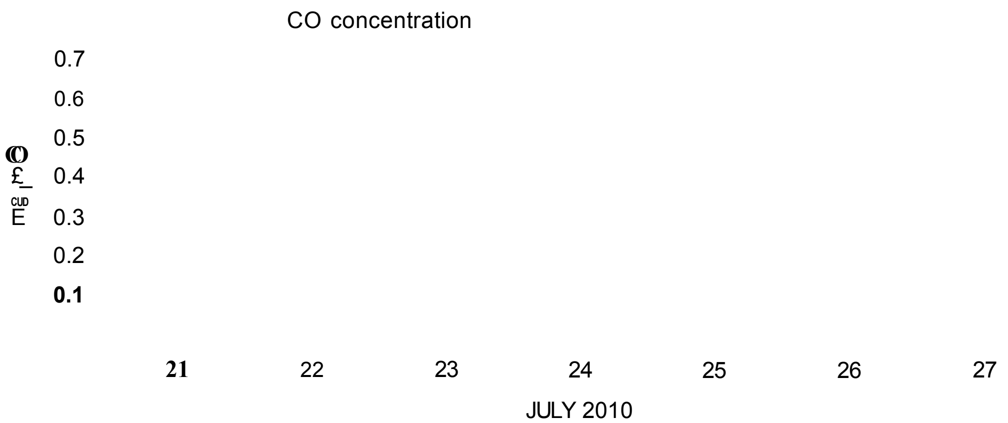


Figure 5.17 CO concentrations

The concentrations of 0_3 emissions were 39.0, 35.6, 38.6, 36.4, 64.6, 65.4 and 67.2 |jg/m_3 for 21-27 July 2010,respectively (Figure 5.18).

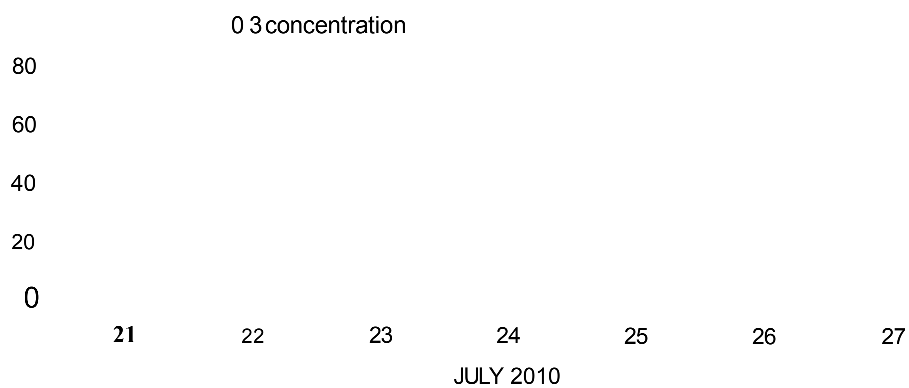


Figure 5.18 0_3 concentration.

5.3.4. Discussion of results

5.3.4.1. Particulate Matters

The highest value for the average concentration of PM2.5 was recorded on 22/07/2010 and, according to the measurements for each half hour, the highest value was 110.8 (jg/m3 at 4am. It was observed that the lowest value of concentration of $PM_{2.5}$ was recorded on 25/07/2010, when the measured value was 11.9 |jg/m3.

The highest concentrations of pollutants every day were from 6 am to 9am, 2pm to 3pm and 8 pm to 11.30pm. These times synchronized with the peak times of traffic congestion in the city centre, when people were travelling to and from work, school and shopping. The highest concentration was 110.8pg/m3 at 4.30am on 22July 2010. This was because of the entry of a merchant ship to the port which is near to the area where the mobile lab was located.

5.3.4.2. Nitrogen oxides

The concentrations of air pollutants recorded by the mobile laboratory every half hour indicated that the high and low concentrations of nitrogen oxides during the period 21-27 July 2010 occurred at the expected times of the day. The detailed results about the concentrations of nitrogen oxides every 30 minutes show that the rise in the value of concentrations started from 6:30am to 9:30am and then gradually declined until 1.30pm. Then, the concentration began to rise again and continued until 3:30pm. After that, low concentrations were recorded until 8 pm, when an increase in the value of the concentrations started again from 8 pm to midnight, then lower concentrations of nitrogen oxides were recorded froml.OOam until 6:00am.

According to the above evidence, higher concentrations of nitrogen oxides were recorded at times when the traffic congestion was severe on the roads. One of these was in morning, from 6am to 9.30am, when people were travelling to school, university and various work locations, when there was traffic congestion on the roads adjacent to the location of the mobile lab. The other time when the value of the nitrogen oxides concentration increased was during the period 1.30pm to 3.30pm. This coincided with the peak traffic congestion on the roads when people return from work and school, and is also a time for shopping and commercial activities. The third period of increase in concentration was from 8pm to midnight. This period witnessed traffic congestion on the roads in the city centre because the high temperatures in summer force people to go to the beach and parks to find more moderate temperatures, and these locations are near to the city centre.

The data above indicate that there is a significant relationship between increased rates of traffic congestion times and increased concentrations of nitrogen oxides released by cars in Tripoli city centre.

5.3.4.3. Carbon monoxide

The highest value of CO concentration in Tripoli city centre was observed at 7.00 am on 27 July 2010, while the lowest concentration was measured at 1.30am on 25 July 2010.The times for high concentrations of carbon monoxide were similar to those of other pollutants, as it was noted that the highest concentration of CO was recorded from 7am to 7.30am each day and also from8pm to 9.30pm. The third period of higher concentrations of CO was from midnight to 12.30 am. These times of day were the times of traffic congestion on the road networks, as already mentioned in the previous sections.

5.3.4.4. Ozone

The data on O_3 concentration provided by the mobile laboratory indicated that the highest concentration of O_3 recorded from the measurements every half hour was found to occur at 2am on 27/07/2010, while the lowest ozone concentration was recorded at1:30am on 24/07/2010. The highest value of O_3 concentration was observed at the peak of traffic congestion, which occurred during the early morning, at midday and late of night.

5.4. Comparison of measured data with Sheffield City (UK)

This section aims to compare the concentrations measured by a mobile lab in Tripoli city centre with the concentrations of the same emissions measured in Sheffield city centre (UK) during the same period. This will provide more insights into the scale of the concentration of vehicular emissions in Tripoli city and the extent to which these concentrations are higher than the required limits, compared with other cities such as Sheffield, UK.

5.4.1. Description of Sheffield

The city of Sheffield is one of the largest cities in England; it is located within the country of south Yorkshire, Sheffield is geographically diverse, being established on the slopes of seven hills and at the confluence of five rivers. The lowest point in the city is located at an altitude of 10 metres above sea level. The city is characterized by sizeable green space and large numbers of trees. It is estimated that there are more than two million trees, making the per capita share of trees in the city of Sheffield higher than in any other city in Europe. Sheffield has more than 170 forests, 78 parks and 10 public parks.

In addition, it contains an estimated area of 135 km2 of national parks, and approximately 11 km2 of water. These figures indicate that 61% of the city is green space (Burke, 2010); Sheffield's population was estimated to be555,500 inhabitants in 2010.

5.4.2. Vehicular emission concentrations in Sheffield city centre

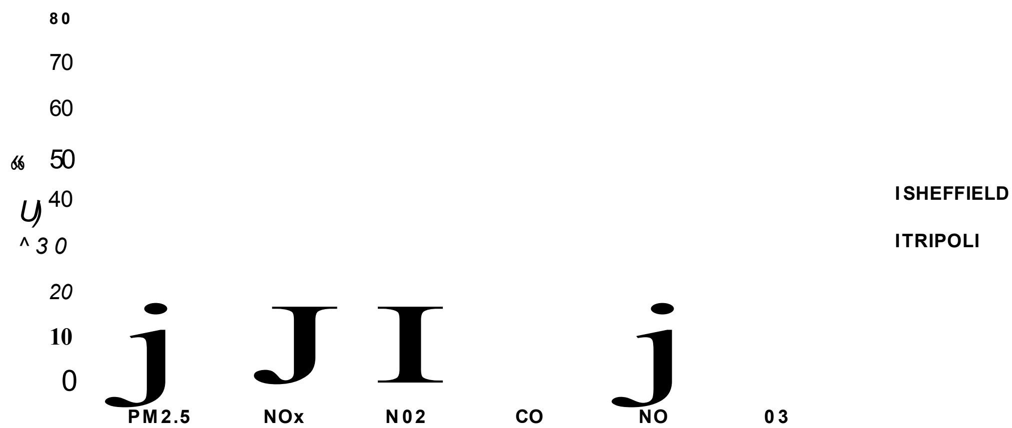
Data on vehicular emission concentrations in Sheffield were obtained from the city's air pollution monitoring system for the same period (21-27/07/2010) in order to compare with the concentrations measured in Tripoli. Table 5.4 below shows the concentrations of PM, NOx, N02, CO, NO and 03 emissions in Sheffield city centre for 21-27 July 2010.

Table 5.4 Emissions concentrations in Sheffield city centre (UK) for 21-27 July 2010. (N.D = No data available).

Date	PM2.5 pg/m3	NOx pg/m3	N02 pg/m3	CO mg/m3	NO pg/m3	03 pg/m3
21.07.2010	10	46	28	0.2	12	36
22.07.2010	14	50	32	0.2	12	25
23.07.2010	13	55	36	0.2	13	38
24.07.2010	11	48	25	0.2	15	37
25.07.2010	10	16	12	0.1	3	49
26.07.2010	N.D	37	25	0.2	8	N.D
27.07.2010	N.D	51	35	0.1	11	N.D

5.4.3. Comparison of vehicular emissions concentration in both cities

Table 5.5 below shows the concentrations of vehicular emissions in both Tripoli (Libya) and Sheffield (UK) for 21-27 July 2010 (Figures 5.19-5.25).



:igure 5.19 Comparison of concentrations in both cities on 21.07.2010

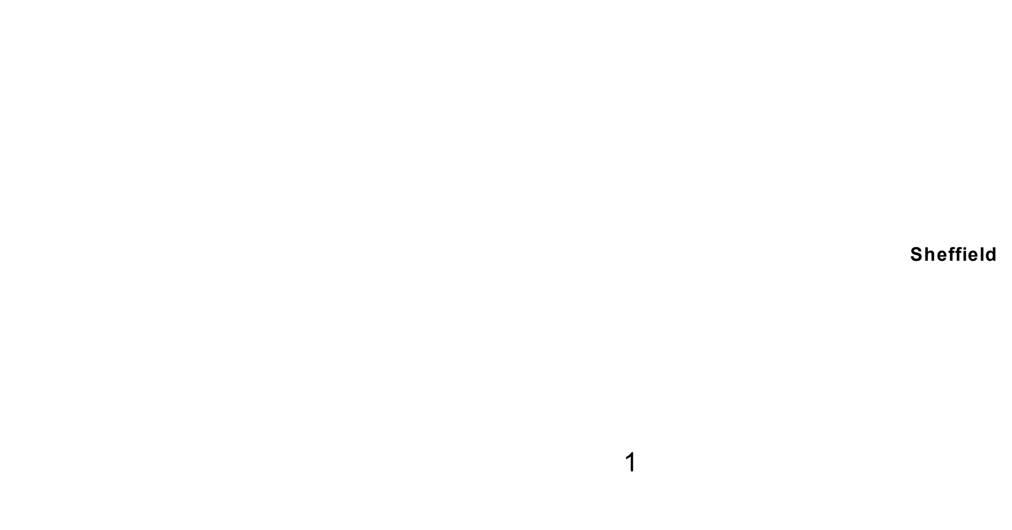


Figure 5.20 Comparison of concentrations in both cities on 22.07.2010

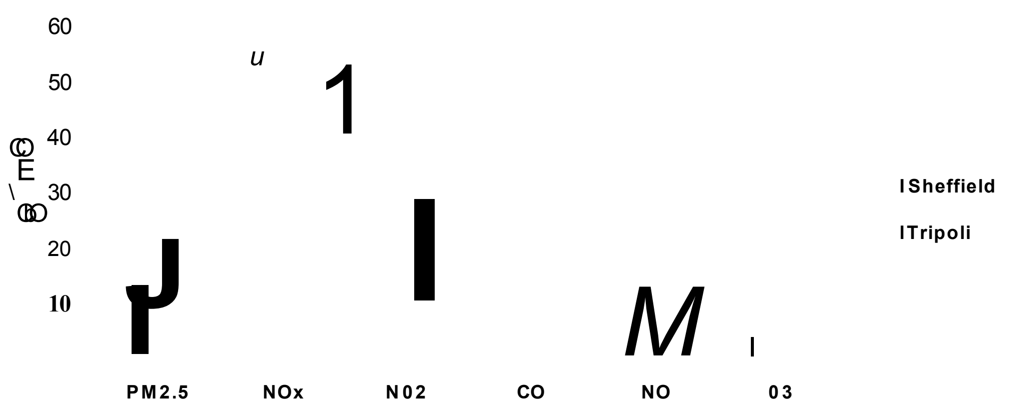


Figure 5.21 Comparison of concentrations in both cities on 23.07.2010

Figure 5.22 Comparison of concentrations in both cities on 24.07.2010

Figure 5.23 .Comparison of concentrations in both cities on 25.07.2010

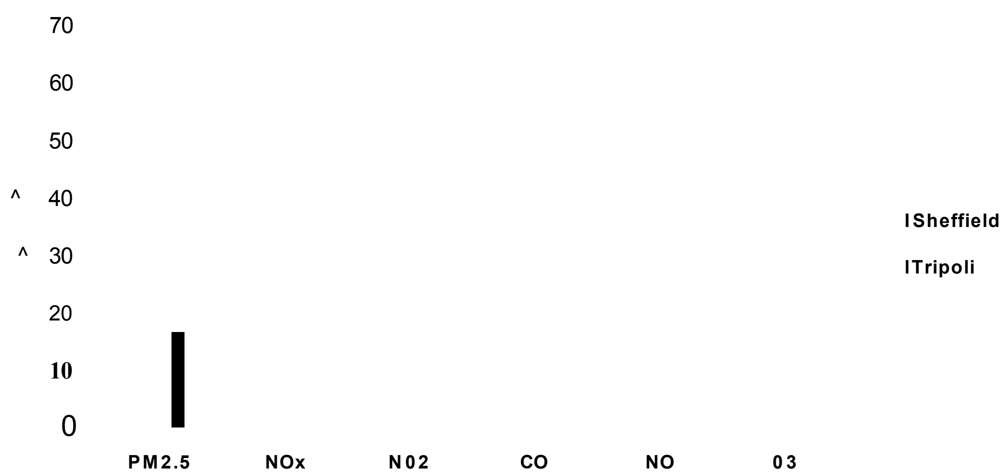


Figure 5.24.Comparison of concentrations in both cities on 26.07.2010

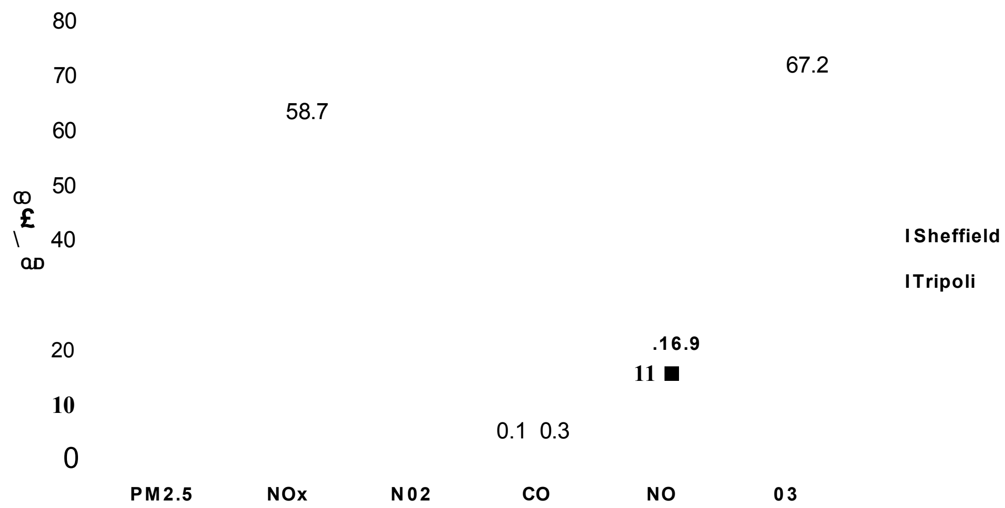


Figure 5.25 Comparison of concentrations in both cities on 27.07.2010.

Table 5.5 Emissions concentrations in both Tripoli city centre (LY) and Sheffield city Centre (UK) for 21-27 July 2010 (N.D = No data available, T= Tripoli, S= Sheffield).

July 2010	PM2.5 (MQ/m3)		NOx (pg/m3)		N02 (pg/m3)		CO (mg/m3)		NO (pg//m3)		0 3 (pg/m3)	
	T	**S**	T	**S**	T	**S**	T	**S**	T	**S**	T	**S**
21	27.5	10	74.6	46	44.4	28	0.6	0.2	20.1	12	39.0	36
22	33.3	14	74.4	50	44.9	32	0.6	0.2	19.6	12	35.6	25
23	21.0	13	48.3	55	32.3	36	0.4	0.2	10.6	13	38.6	38
24	23.1	11	84	48	45.9	25	0.6	0.2	25.2	15	36.4	37
25	15.9	10	56.2	16	30.3	12	0.4	0.1	17.3	3	64.6	49
26	15.9	N.D	59.6	37	29.5	25	0.4	0.2	20	8	65.4	N.D
27	20.4	N.D	58.7	51	33.5	35	0.3	0.1	16.9	11	67.2	N.D
27.	20.4	N.D	58.7	51	33.5	35	0.3	0.1	16.9	11	67.2	N.D

5.4.3.1. The highest and lowest average concentrations in both cities

Table 5.6 below shows that the highest average concentration of $PM_{2.5}$, NOx, N02, NO, CO and 0 3 in both cities.

Table 5.6 The highest and lowest emissions concentration in both Tripoli city centre (LY) and Sheffield city centre (UK).

Pollutants	Highest average concentration		Lowest average concentration	
	Tripoli	Sheffield	Tripoli	Sheffield
PM2.5 (pg/m3)	33.3	14	15.4	10
NOx (pg/m3)	84	55	48.3	16
N02 (pg/m3)	45.9	36	29.5	16
NO (pg/m3)	25.3	15	10.6	3
CO (mg/m3)	0.6	0.2	0.5	0.2
03 (pg/m3)	67.2	49	35	25

5.4.4. Discussion of the results of the comparison

The data obtained on the concentrations of air pollutants emitted from cars in both cities, Tripoli in Libya and Sheffield in the United Kingdom, were measured during the same period (21-27 July 2010), using two different methods.

The concentrations in Tripoli were measured using a mobile laboratory while the measurements that took place in the city of Sheffield were carried out by automatic monitoring sites and surveillance available in the city.

A large number of factors and data can affect vehicle pollution in every city, including the population, number of fleet vehicles, type of fuel consumed, weather conditions, conditions of the road network and severity of the traffic congestion. This is in addition to the local legal and administrative systems and management of traffic on the road network, particularly within the city centre. Despite the role that can be played by all of these elements in the concentrations recorded in both cities, this comparison is nevertheless useful for illustrating the extent of the concentration of traffic air pollutants in Tripoli compared to another city. Sheffield was selected, as the researcher is studying in this city, enabling him to obtain measurements of the concentrations of traffic air pollutants over the same measurement period and for the same traffic air pollutants as in Tripoli.

A comparison between the concentrations of air pollutants emitted from cars in both cities indicated that the concentrations of all pollutants measured were higher in Tripoli than in Sheffield, across the whole period (21-27 July 2010). This can be seen from the highest values observed for concentrations of pollutants. It was noted that the lowest value of concentrations of pollutants measured in Tripoli is higher than the highest value measured in Sheffield for most of the vehicular pollutants measured.

5.5. Chapter Summary

This chapter presents the vehicular emissions for the period 2005-2010 in Tripoli, obtained by applying COPERT.4 software. COPERT is a software tool developed by the European Environment Agency (EEA), which is widely used to calculate emissions from road transport.

The situation of the study area concerning the inventory of the vehicular emissions is the same as that in most developing countries, and routine inventory and measurements of air pollutants were unavailable, as no inventory had been carried out for air pollutants, including vehicular pollutants, across the whole country.

The chapter also presented the concentration of air pollutants caused by motor vehicles, measured with the aid of the mobile lab during the period 21-27 July 2010, in Tripoli city centre. The data were compared with the concentrations of the same emissions measured in Sheffield city centre (UK) during the same period. The comparison indicated that the concentrations of all pollutants measured were higher in Tripoli than in Sheffield, over the whole period. The data gathered from the inventory together with the analyses of the questionnaire (which will be presented in the next chapter) will be used as evidence during the discussion of the research findings.

Chapter Six

Analysis of the Questionnaire

6.1. Introduction

The main aims of this chapter are to analyse and evaluate the views and opinions of the respondents about air pollution caused by motor vehicles in Tripoli. The questions were selected based on the objectives of the research as well as according to the knowledge gathered through the literature review (AppendixI).

The questions of the questionnaire were arranged into eight groups as follows:

i. Air quality status in the city of Tripoli.

ii. Contribution of motor vehicles to air pollution in Tripoli.

iii. Air pollution caused by motor vehicles in Tripoli and the factors which have led to this problem.

iv. Effects of air pollution caused by motor vehicles.

v. Actions taken and relevant policies to address air pollution caused by vehicles in the city of Tripoli.

vi. Achievement needed to reduce the reliance on private vehicles for travel in Tripoli.

vii. Available options for reduction of air pollution caused by vehicles in Tripoli.

viii. Management strategy to reduce air pollution caused by motor vehicles in Tripoli and the required instruments.

6.1.1. The population and sample

The Sample Size was calculated to determine how many respondents needed to complete the questionnaire in order to obtain results that reflect the target population. A sample of 200 individuals from the population of 1,161,960 inhabitants gives a confidence interval of 6.93 at a 93% confidence level, as shown in table 6.1 below.

Table 6.1 Sample Size

Determine Sample S

Confidence Level:	95%
Confidence Interval:	
Population:	
Sample size needed:	

Two hundred individuals were selected from the population of the study. These samples were residents of the city, at least 18 years old, with varied gender and educational levels, who were selected from different locations across the study area.

A total of 200 questionnaires were distributed to selected respondents, of whom 158 respondents answered all the questions. Fourteen copies that were received from respondents were rejected as they were incomplete. The final return rate was 79%.

6.2. Method of questionnaire data analysis

For the purpose of undertaking a quantitative analysis of the data collected through the questionnaire, SPSS Software (Statistical Package for Social Sciences) was used, as this package is one of the most commonly applied in the field of Social and Human Sciences. SPSS is used widely all over the world, as it can provide regular, strong analyses of the collected data (Bryan, 2001).

6.2.1. Coding data

For the purpose of entering the questionnaire data into SPSS Software, a code book was developed to code the propositions involved in the questionnaires. Some numerical values were used to represent some of the categorised data gathered through the questionnaire, as follows:

6.2.1.1. Dependent Variables

The dependent variables include the gender, age and level of education of the respondents.

6.2.1.1.1. Gender of the respondents

The gender of the respondents was coded in SPSS with males represented by 1 and females repressed by 2, as shown in table 6.2 below.

Table 6.2 Gender variables

Gender of Respondents	Categories
Male	1
Female	2

Of the 158 respondents who answered the questions, 86 were male (representing 54.4% of the respondents) and 72 were females (representing 45.6% of the respondents).

6.2.1.1.2. Age of the Respondents

The respondents was divided into four categories of age and coded in SPSS as follows:

In SPSS, the age group < 20 were represented by 1, age group 20-39 by 2, age group 40-59 by 3, and age group 59+ by 4, as shown in table 6.3 below.

Table 6.3 Ages of Respondents

Age of respondent	Categories
<20	1
20-39	2
40-59	3
59+	4

6.2.1.1.3. Education of Respondents

The education of the respondents was divided into four categories in SPSS. Primary education was represented by 1, secondary education by 2, university education by 3 and higher education (including Master's and PhD degrees) by 4, as shown in table 6.4 below.

Table 6.4 Education of the Respondents

Level of education	Categories
Primary education	1
Secondary education	2
University	3
Higher education	4

6.2.1.2. Independent variables

Four kinds of categories were used to identify the answers of the respondents to the various questions presented on the questionnaire for the independent variables. The first method was for no and yes answers, represented in SPSS by 1 and 2, respectively. The second was for three answers; always, partly and never, which were represented on SPSS by 1-3, respectively. The third was for four answers; completely agree, agree, neutral and completely disagree, represented in SPSS by 5-1, respectively. The fourth was for five answers: excellent, good, acceptable, poor and very poor, which were represented in SPSS by 1-5, respectively.

The second step in the questionnaire analysis was to multi-check the data that had been entered into SPSS in order to ensure that all of them had been correctly entered. The types of analyses done included the following:

1. Frequency and percentages of the respondents.

2. The chi-square test.

The results of the questionnaire analysis are as follows:

6.3. Research question one: air quality status in Tripoli city

Q1. How would you describe the air quality in Tripoli?

The respondents were asked how they would describe the air quality in Tripoli. As shown in table 6.5, most of the respondents believed that the air quality status was acceptable, while a few (6.3%) thought that it was good and 30.4% believed that Tripoli had a poor status of air quality.

Table 6.5 Frequency and percentage of perceptions of air quality in Tripoli

		Frequency	Percent
Valid	Excellent	2	1.3
	Good	10	6.3
	Acceptable	91	57.6
	Poor	48	30.4
	Very Poor	7	4.4
	Total	158	100.0

We can conclude that the majority of the respondents considered that the air quality in Tripoli is acceptable.

Table 6.6 The perceptions of the dependent variables on air quality in Tripoli

Dependent variables		Excellent	Good	Acceptable	Poor	Very Poor
Gender	Male	0	6	47	27	6
	Female	2	4	44	21	1
	Total	2	10	91	48	7
Age	< 20	0	0	2	2	0
	20-39	1	6	57	26	2
	40-59	1	4	31	17	4
	> 59	0	0	1	3	1
	Total	2	10	91	48	7
Education	Primary	0	0	8	5	2
	Secondary	2	1	13	16	1
	University	0	7	64	21	3
	Higher Education	0	2	6	6	1
	Total	2	10	91	48	7

Table 6.6 shows that a slightly higher proportion (57.6%),47 of the respondents who believed that the air quality in Tripoli is acceptable were male (compared with, 44% for females). The 20-39 age group contained a higher number of people, 57 of the respondents who believed that the air quality is acceptable.

6.4. Research question two: air pollution caused by motor vehicles in Tripoli.

This question considered the sources of air pollution in the Tripoli as well as the air pollution caused by motor vehicles in Tripoli.

Q2.1. What do you consider to be the cause of air pollution in Tripoli?

Table 6.7 Frequencies and percentages for the perceptions about the sources of air pollution in Tripoli.

Perceptions about the sources of air pollution	Yes	No
A r pollution by motor vehicles	136	22
A r pollution by waste disposal	78	80
A r pollution by industries	57	101
A r pollution by toxic substances	41	116
A r pollution by heating/cooling systems	31	126
A r pollution by power generation	20	137
A r pollution by other sources	11	146
A r pollution by agriculture	8	150
A r pollution by natural sources	5	152

The respondents were asked their opinions concerning the main sources of air pollution in Tripoli. As shown in Table 6.7 above, 136 (86.1%) of the respondents believe that vehicles are the major source of air pollution in the city, which they attributed to an increase in the vehicle fleet and traffic congestion. Other sources of air pollution, for example, from industries and agricultural activities, attracted a lower response.

Q2.2.To what extent do you agree or disagree with the statement that motor vehicles cause air pollution in Tripoli ?

Table 6.8 Frequency and percentage of the perceptions of the statement that motor vehicle cause air pollution in Tripoli.

	Frequency	Percent
Completely disagree	5	3.2
Disagree	1	.6
Neutral	5	3.2
Agree	56	35.4
Completely Agree	91	57.6
Total	158	100.0

The respondents were asked about the air pollution caused by motor vehicles. As shown in Table 6.8 above, 93% of the total respondents believe that motor vehicles emit air pollutants in the study area.

Table 6.9 The perceptions of the respondents on air pollution caused by vehicles in Tripoli based on the dependent variables

Dependent variables		Completely disagree	Disagree	Neutral	Agree	Completely agree
Gender	Male	1	0	4	38	43
	Female	4	1	1	18	48
	Total	5	1	5	56	91
Age	< 20	0	0	0	1	3
	20-39	2	0	3	39	48
	40-59	3	1	2	16	35
	> 59	0	0	0	0	3
	Total	5	1	5	56	91
Education	Primary	1	0	0	3	11
	Secondary	2	1	3	8	19
	University	2	0	2	39	52
	Higher Education	0	0	0	6	9
	Total	5	1	5	56	91

Table 6.9 demonstrates that males form a relatively higher proportion of the respondents who either agree or completely agree that the air pollution in Tripoli is produced as a result of vehicles. In terms of age, the 20-39 age group were contained a relatively higher proportion of those who either agreed or completely agreed with this statement. In terms of level of education, a relatively higher number of respondents (91) with a university education agreed that, the air pollution in Tripoli resulted from vehicles. Underlying causes these percentages of gender, age and level of education are due to the following:

1. In terms of the gender of the respondents, 55% of the total respondents to the questionnaire were male, and there were only 45% females, so males form a higher proportion of respondents.

2. In terms of age group, the majority of the 20-39 age group was educated, as they are studying at or had already graduated from university and so may be considered as an informed person regarding such issues.

3. In terms of level of education, participants with a university education form the majority of the respondents.

6.4.1. Chi-Square test

A chi-square is a statistical test that is commonly used to compare observed data with the data which would expect to be obtained according to a specific hypothesis. The chi-square test always tested the null hypothesis (HO),which states that there is no significant difference between the expected and observed result, and the Alternative Hypotheses (H-i), which states that there is a significant difference between the expected and observed results.

The chi-square test was used to explore how the gender, age and level of education (independent variables) of the respondents are associated with the problem of air pollution caused by motor vehicles in Tripoli (the dependent variable). Both variables could be identified as:

1- Problem - air pollution caused by motor vehicles as a dependent variable.

2- Gender of respondents as an independent variable.

3 - Age of respondents as an independent variable.

3. Level of education as an independent variable

6.4.1.1 The Hypotheses

In this test, the following hypotheses will be tested:

1. Gender has a significant association with the problem of air pollution caused by vehicles.

2. There is a significant association between age and the problem of air pollution caused by vehicles.

3. There is a significant association between the level of education and problem of air pollution caused by vehicles.

The testing of the hypothesis will be implemented based on the following types:

- Null Hypotheses (H0) where no association exists between the variables.

- Alternative Hypotheses (H-i) where there exists a significant association between the variables.

6.4.1.2. Problem - air pollution caused by motor vehicles

Table 6.10 shows that 57.6% of the respondents completely agreed that air pollution is caused by vehicles, with a further 35.41% agreeing compared with just 0.6% disagreeing and a further 3.2% completely disagreeing that the problem of air pollution is caused by vehicles.

Table 6.10 Frequency and percentage of perceptions on air pollution caused by vehicles.

	Frequency	Percent
Completely disagree	5	3.2
Disagree	1	.6
Neutral	5	3.2
Agree	56	35.4
Completely Agree	91	57.6
Total	158	100.0

6.4.1.3. Bivariate and hypotheses testing

6.4.1.3.1. Gender and the problem of air pollution caused by vehicles

By using the chi- square tests in table 6.12, it was found that the chi-square = 10.862, $p > 0.05$, which leads to the acceptance of H1f showing an association between gender and the perceptions of the problem of air pollution caused by vehicles.

Table 6.11 Gender of the respondents who agree with the statement that air pollution is caused by motor vehicles.

Gender of respondents * air pollution caused by vehicles. Cross tabulation

		Air pollution caused by vehicles				
		Completely disagree	Disagree	Neutral	Agree	Completely agree
Gender of respondents	Male	1	0	4	38	43
	Female	4	1	1	18	48
Total		5	1	5	56	91

Table 6.12 Chi-Square tests for gender of respondent with the air pollution problem caused by motor vehicles.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.8623	4	.028
N of Valid Cases	158		

a. 6 cells (60.0%) have an expected count of less than 5. The minimum expected count is .46.

To verify the strength of the relationship between gender and the problem of air pollution caused by vehicles the Cramer's V (table 6.15). I the Cramer's V is closer to the value of +1,then the association will be strong. From Table 6.15 below, we can note that the Cramer's V is 0.262, which gives a weak association between gender and the perceptions of the air pollution problem.

Table 6.13 The Cramer's measures for the relationship between gender and the problem of air pollution caused by vehicles.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Cramer's V	.262	.028
N of Valid Cases		158	

a. Not assuming the null hypothesis.

6.4.1.3.2. Age and problems of air pollution caused by vehicles

According to the chi-square tests as indicated in table 6.15 below, the calculated chi-square = 9.851, $p < 0.05$, so we can accept the null hypothesis (H0) that no association between age and the perception of air pollution caused by vehicles is formed.

Table 6.14 Age of respondent * air pollution caused by vehicles. Cross tabulation

	Air pollution caused by vehicles					
Age of respondents	Completely disagree	Disagree	Neutral	Agree	Completely Agree	Total
<20	0	0	0	1	3	4
20-39	2	0	3	39	48	92
40-59	3	1	2	16	35	57 ;
> 59	0	0	0	0	5	5
Total	5	1	5	56	91	158

Table 6.15 Chi-square tests for age of respondent with the air pollution problem caused by motor vehicles.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.851a	12	.629
N of Valid Cases	158		

a. 16 cells (80.0%) have an expected count of less than 5. The minimum expected count is .03.

6.4.1.3.3. Level of education and problems of air pollution caused by vehicles

Table 6.17 showed that the chi-square = 14.908, $p > 0.05$, which demonstrates that Hi shows an association between level of education and perceptions that the problem of air pollution is caused by vehicles.

Table 6.16 education of the respondents * air pollution caused by vehicles.

Cross tabulation

		Air pollution caused by vehicles.					Total
		Completely disagree	Disagree	Neutral	Agree	Completely Agree	
Level of respondents' education	Primary education	1	0	0	3	11	15
	Secondary education	2	1	3	8	19	33 ;
	University	2	0	2	39	52	95
	Higher education	0	0	0	6	9	15
	Total	5	1	5	56	91	158

Table 6.17 Chi-square tests for levels of education of the respondent with the perception of air pollution problem is caused by motor vehicles.

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.9083	12	.247
N of Valid Cases	158		

a. 12 cells (60.0%) have an expected count of less than 5. The minimum expected count is .09.

To verify the strength of the relationship between the level of education and the perception that the problem of air pollution is caused by vehicles, the Cramer's V (table 6.18) can play this role where it depends on its value. From Table 6.20 above, we can note that the Cramer's V is 0.177, which gives a weak association.

Table 6.18 Cramer's measures of the relation between the levels of education and perceptions of air pollution caused by vehicles.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Cramer's V	.177	.247
N of Valid Cases		158	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

6.4.1.4. Conclusion

According to the chi-square tests, we can conclude the following points:

1. For the gender of the respondents, Hiwas accepted, which showed that a significant association existed between gender and the perception that the problem of air pollution is caused by vehicles.

2. For the age of the respondents, H0was accepted, which showed that no association existed between age and the perception that the problem of air pollution is caused by vehicles.

3. Regarding the education of the respondents, Fhwas accepted, which showed an association between the level of education and perception that the problem of air pollution is caused by vehicles.

6.5. Research question three: the factors affecting air pollution in Tripoli

Q3.To what extent do you agree or disagree with the statements about the major affecting factors that have contributed to the increased air pollution caused by motor vehicles in Tripoli?

The respondents were asked about their perceptions about what has contributed towards increasing vehicle-derived air pollution. Table 6.19 illustrates that the majority of the respondents stated they completely agreed that the most significant affecting factors that contributed to air pollution caused by vehicles in Tripoli were:

1. The increased vehicle fleet.
2. Lack of public transport.
3. Lack of environmental public awareness.
4. Weakness of national environmental law.
5. Increase in traffic congestion.

The less significant affecting factors were ranked as follows:

1. Increase in population growth.
2. Increase in economic growth.
3. Increase in fuel consumption
4. Weather conditions.

This ranking of the most significant affecting factors was consistent with that found in previous studies as well as from field visits to the study area; it further corresponds with the information obtained through the personal interviews. This will be discussed in Chapter Eight.

Table 6.19 The perceptions about the most significant affecting factors that have contributed to air pollution caused by vehicles in Tripoli.

Affecting factors	Completely disagree	Disagree	Neutral	Agree	Completely Agree
Increase in the vehicle fleet	5	9	4	60	79
Lack of a public transport sector	5	12	15	59	67
Lack of environmental awareness	5	13	12	64	64
Weakness of the environmental law	4	5	25	80	63
Increased traffic congestion	3	14	17	71	49
Increased population growth	7	18	8	76	48
Increased economic growth.	11	15	28	75	27
Increased fuel consumption	6	19	45	65	22
Weather conditions	10	26	52	52	18

6.6. Research question four: Effects of air pollution caused by motor vehicles in Tripoli

This question includes three sub-questions on the effects of air pollution caused by vehicles; health, environmental, economic and climatic effects.

Q4 (1-3) To what extent do you agree or disagree with the statement that there are health, environment, economic and climatic effects of air pollution caused by motor vehicles in Tripoli?

Table 6.20 The perceptions of the effects of air pollution by vehicles in Tripoli.

The effects	Completely disagree	Disagree	Neutral	Agree	Completely Agree
Health effects.	10	5	8	68	67
Environmental effects	2	11	17	67	60
Economic effects	5	12	23	83	35
Climate effects	8	20	46	61	23

Table 6.20, demonstrates that health effects are seen to be the most significant effects resulting from air pollution caused by vehicles in Tripoli, as the majority of the respondents (85.44%) agreed or completely agreed with this statement. 80.38% of the respondents believe that there are environmental effects, while economic and climatic effects attracted lower response rates.

6.6.1. Analysis of the relationship between perceptions of health effects and public transport use

This section seeks to define the relation between the perceptions of the health effects of air pollution caused by vehicles and those of public transport use by cross-tabulation.

Table 6.21. Health effects * public transport use. Cross-tabulation

Health effects	Public transport use			
	Always	Partly	Never	Total
Completely disagree	2	6	2	10
Disagree	1	3	1	5
Neutral	2	3	3	8
Agree	9	37	22	68
Completely Agree	6	41	20	67
Total	20	90	48	158

Based on Table 6.21, we can note that the majority of the respondents who agreed or completely agreed with health effects were also partly those who have used public transport.

6.6.2. Analysis of the relation between perceptions of the health effects and factors affecting air pollution caused by vehicles

This section seeks to define the relation between the perceptions of the health effects of air pollution caused by vehicles and the perceptions of the factors affecting air pollution caused by vehicles in Tripoli, which have already been presented in Q3 of this chapter.

6.6.2.1. Health effects and the increased vehicle fleet as a factor affecting air pollution caused by vehicles

Table 6.22. Health effects * Affecting Factors. Cross tabulation

Health effects	Increased vehicle fleet					Total
	Completely disagree	Disagree	Neutral	Agree	Completely Agree	
Completely disagree	3	0	0	0	7	10
Disagree	0	0	1	3	1	5
Neutral	0	3	1	3	1	8
Agree	2	2	1	43	20	68
Completely Agree	6	41	0	0	20	67
Total	11	46	3	49	49	158

From Table 6.22 above, it is highlighted that the majority agrees/completely agrees that an increase in the vehicle fleet is a factor.

6.6.2.2. Health effects and increased fuel consumption as a factor affecting air pollution caused by vehicles

As shown in Table 6.23 below, there is a neutral response to agree/completely agree that health effects are caused by fuel consumption, suggesting that the respondents may believe that newer vehicles are more efficient.

Table 6.23.Health effects * Affecting Factors. Cross tabulation.

Health effects	Increase in fuel consumption					Total
	Completely disagree	Disagree	Neutral	Agree	Completely Agree	
Completely disagree	0	2	2	2	4	10
Disagree	0	0	0	1	1	5
Neutral	0	4	2	2	0	8
Agree	2	8	20	30	8	68
Completely Agree	4	7	19	28	9	67
Total	6	21	43	63	22	158

6.6.2.3. Health effects and the increased non-implementation of environmental law as a factor affecting air pollution caused by vehicles.

Table 6.24.Health effects * Affecting Factors. Cross tabulation.

Health effects	Non implementation of environmental law					Total
	Completely disagree	Disagree	Neutral	Agree	Completely Agree	
Completely disagree	0	1	2	1	6	10
Disagree	0	1	2	2	0	5
Neutral	0	0	4	3	1	8
Agree	0	2	14	30	22	68
Completely Agree	4	1	3	25	34	67
Total	4	5	25	61	63	158

From Table 6.24 above, we can conclude that agree/completely agree are predominant in terms of believing that the lack of environmental law and non-implementation may be responsible for the level of air pollution perceived.

6.6.2.4. Health effects and the increased lack of environmental public awareness as a factor affecting air pollution caused by vehicles

Table 6.25.Health effects * Affecting Factors. Cross tabulation.

Health effects	Lack of environmental public awareness					Total
	Completely disagree	Disagree	Neutral	Agree	Completely Agree	
Completely disagree	0	3	1	2	4	10
Disagree	0	0	0	3	2	5
Neutral	0	0	2	5	1	8
Agree	1	7	5	28	27	68
Completely Agree	4	3	4	26	30	67
Total	5	13	11	64	64	158

From Table 6.25, we can conclude that the respondents agree/completely agree that the lack of public environmental awareness may have contributed to the increased rates of air pollution caused by vehicles.

From Table 6.25, we can conclude that the respondents agree/completely agree that the lack of public environmental awareness may have contributed to the increase in the air pollution rates caused by vehicles.

6.7. Research question five: The actions taken and relevant policies to address air pollution caused by vehicles in the city of Tripoli.

This section is divided into two sub-sections; the first section concerns the roles of the local authorities in addressing the problem and status of the national legislation. The second section concerns the actions taken to address the problem and policies available for addressing air pollution caused by motor vehicles in Tripoli.

6.7.1. The roles of the local authorities in addressing the problem and the status of the national legislation.

This section includes two sub-sections:

1. The roles of the local authorities

2. The status of environmental law and relevant regulations.

To cover all of these measures, the respondents were asked the following questions:

Q5.1 To what extent do you agree or disagree with the statement that the EGA and traffic police have taken effective action to address air pollution caused by motor vehicles?

Table 6.26 The perceptions on the roles of the local authorities in addressing air pollution caused by vehicles in Tripoli.

The local authority	Completely disagree	Disagree	Neutral	Agree	Completely Agree
The Role of EGA	54	71	21	4	8
The Role of GTL	46	70	24	12	6

Table 6.26 shows that 79.11% of the total respondents disagreed and completely disagreed that the EGA performed the tasks required to address air pollution caused by vehicles in Tripoli. In terms of the roles of GTL, 73.41%

disagreed and completely disagreed that GTL had achieved the tasks needed to address the problem.

Q5.2.To what extent do you agree or disagree with the statement that the local responsible institutions face obstacles and difficulty in their roles in terms of addressing air pollution caused by vehicles?

Table 6.27 Frequency and percentage of the perceptions of the obstacles and difficulties facing the roles of the local institutions.

	Frequency	Percent %
Completely disagree	9	5.7
Disagree	13	8.2
Neutral	33	20.9
Agree	63	39.9
Completely Agree	40	25.3
Total	158	100.0

Table 6.27 shows that 65.2% of the total respondents agreed or completely agreed that the local authorities faced obstacles and difficulties.

The majority of the respondents believe that the authorities suffered, which was later confirmed through interviews carried out by the technical staff of institutions (see Chapter Seven). The observations made through the fieldwork in Tripoli showed that the local authorities lack the instruments and equipment required to monitor and control the problem (see Chapter Four).

Q5.3. The respondents were asked about the quality of the environmental law and traffic law in terms of covering the issue of air pollution caused by vehicles. The question included some relevant measures on these laws.

Table 6.28 the perceptions of the respondents on the status of the environment law and traffic law.

Legislation measures	Yes	No
The environmental law is sufficient.	13	145
Non-compliance with the environmental law	97	61
The traffic law is sufficient	69	89
The laws are effectively implemented	16	142
Laws are required for amendments	135	23
The legislation and regulations need to be developed.	102	56

Table 6.28 demonstrates that 91.77% of the total respondents believed that the environmental law is insufficient, while 61.39% believed that there was no compliance with the environmental law. In terms of the traffic laws, 56.33% thought that the traffic laws were insufficient, and 89.87% believed that the laws were not implemented effectively. The most significant issues on the status of environmental law and traffic law were ranked according to the perceptions of the respondents as follows:

1. The environmental law is insufficient.

2. The laws were not effectively implemented.

4. The traffic law is sufficient

4. Non-compliance with the environmental law

4. Legislation and regulations need to be developed.

5. The laws require amendments

6.7.2. Actions taken to address the problem in the past and the policies currently available

This section of the questionnaire included two questions; the first question concerned the actions that have been taken by the local authorities in the past few years to address the air pollution problem caused by vehicles in Tripoli, and the second question related to the plans and programmes available for addressing the problem.

Q5.4 To what extent do you agree or disagree with the statement on the actions taken in the past to address air pollution caused by vehicles in the city of Tripoli?

Table 6.29 Frequency and percentage of the perceptions of the actions taken to reduce traffic air pollution

	Frequency	Percent
Completely disagree	23	14.6
Disagree	67	42.4
Neutral	25	15.8
Agree	34	21.5
Completely Agree	9	5.7
Total	158	100.0

Table 6.29 shows that 57% of the total respondents believed that no actions have been taken in the past few years to address air pollution caused by vehicles.

Q5.5 to what extent do you agree or disagree with the statement that the responsible authorities have plans and programmes in terms of reducing air pollution caused by vehicles in Tripoli?

Table 6.30 Frequency and percentage of the perceptions of policies and programmes available to address air pollution caused by vehicles in Tripoli

		Frequency	Percent
Valid	Completely disagree	22	13.9
	Disagree	72	45.6
	Neutral	31	19.6
	Agree	23	14.6
	Completely Agree	10	6.3
	Total	158	100.0

Table 6.30 shows that 59.5% of the total respondents disagreed or completely disagreed that there are available plans or programmes for addressing air pollution caused by vehicles.

6.8. Research question six: the achievement of a reliance on private vehicles to travel in the city of Tripoli.

This section was divided into five questions in order to cover the following measures:

1. Ownership of a private vehicle.
2. Use of a private vehicle.
3. The importance of vehicle ownership.
4. The public transport sector.
5. The need to decrease the reliance on private vehicles to travel.

To cover all of the issues, the respondents were asked the following questions:

Q6.1. Do you own a vehicle?

Table 6.31 Frequency and percentages of the perceptions on vehicle ownership

	Frequency	Percent
No	49	31.0
Yes	108	68.4
	157	99.4
Missed	1	.6
Total	158	100.0

Table 6.31 shows that 68.4% of the total respondents are vehicle owners. Some of the reasons for owning a vehicle were explored.

Q6.2. What do you use the vehicle for?

Table 6.32 The perceptions of the respondents for the purposes of using private vehicles

Purposes of using the vehicle	Yes	No
Travel to work	105	53
Transport children to school	63	95
Visiting family and friends	102	56
Leisure activities	71	87
Shopping	92	66
Business	11	147
Other purposes	7	151

The respondents were asked about the use of their private vehicles. Table 6.32 shows that 66.46% of the total respondents use private vehicles to commute to work, and lower numbers use them for other purposes.

6.8.1. Analysis of the relation between the perceptions of vehicle owners and the use of private vehicles

This section seeks to define the relation between the perceptions of vehicle owners, which are presented in Q6.1, and the perceptions on the purposes of private vehicle use presented in Q6.2. We can conclude the following:

The data obtained from SPSS showed that the perceptions of vehicle owners on the use of private vehicle are as follows:

i. 62.66% commute to work.

ii. 60.13% visit family and friends,

iii. 36.7% transport children to school.

iv. 43.04 % leisure activities and shopping.

v. 5.7% business.

vi. 3.8% other purposes.

We can conclude that the most significant ways of reducing dependence on private cars is to provide transportation means for employment, thereby reducing the need to use private cars to commute, as well as to improve the public transport infrastructure, thus making it easier for citizens to get to work and visit relatives and friends. Reducing the students' needs for transportation through reducing fees or providing good quality of public transport may reduce the reliance on the use of private cars to transport children to school.

Q6.3. If vehicle ownership is important to you, why?

Table 6.33 The perceptions of respondents on the importance of vehicle ownership

Why a vehicle is important	Yes	No
Utility	81	77
Liberty	29	129
Public transport lacking	103	55
Other purposes	20	138
Not important	9	149

The respondents were asked why vehicle ownership is important. As seen in Table 6.33 above, the perceptions of the priority of the importance of using a private vehicle were ranked according to the perceptions of the respondents as follows:

1. The lack of public transport.
2. Utility.
3. Liberty.
4. Other purposes.
5. Not important.

We can note that the main trend of the respondents is to continue to own a private car, so there is a need to involve this issue as a priority in any action plan or strategy for addressing the problem. Additionally, there needs to be more concentration on the public awareness programmes needed to change the behaviour of individuals who rely on vehicle ownership for transportation.

6.8.2. Analysis of the relation between the perceptions of vehicle owners and the perceptions of the importance of vehicle ownership

This section seeks to define the relation between the perceptions of vehicle owners presented in Q6.1 and the perceptions about the importance of vehicle ownership presented in Q6.3.

Based on data obtained from SPSS, the perceptions of vehicle owners of the importance of vehicles are as follows:

i. 22.15% utility.

ii. 52.53% lack of public transport sector.

iii. 17.09% liberty.

iv. 6.96% other purposes.

v. 2.53% not important.

The perceptions of those who did not own vehicles of the importance of owning vehicles were as follows:

i. 46.84% utility.

ii. 16.46% lack of public transport sector.

iii. 51.9% liberty.

iv. 62.03% other purposes.

v. 66.45% not important.

We can conclude that car owners state that the lack of public transport is the main reason for vehicle ownership, whereas those who did not own a vehicle defined a number of possible reasons why they would like to own a vehicle, but interestingly found no lack of public transport to fulfil their transport needs.

Q6.4. Do you use public transport?

Table 6.34 The perceptions of the respondents on public transport use.

	Frequency	Percent
Always	20	12.7
Partly	90	57.0
Never	48	30.4
Total	158	100.0

The respondents were asked about the use of public transport in the city and why vehicle ownership is important, as seen in Table 6.34 above.

6.8.3. Analysis of the relation between the perceptions of vehicle owners and the perceptions of using public transport.

This section seeks to define the relation between the perceptions of vehicle owners presented in Q6.1 and the perceptions of the use of public transport presented in Q6.4.

Table 6.35 The perceptions of vehicle owners on using the public transport sector.

	Vehicle owner		Total
	No	Yes	
Always	17	3	20
Partly	22	68	90
Never	10	38	48
Total	49	109	158

Based on Table 6.35, we can conclude that car owners identified a lack of public transport as a problem (6.8.2), but do make some use of that which is available. Some who do own a vehicle also never use public transport. A small percentage stated they always use public transport even if there is car ownership.

Q6.5. To what extent do you agree or disagree with the statement that people should decrease their reliance on private vehicles to travel?

Table 6.36 Frequency and percentage of the perceptions on decreasing the reliance on private vehicles to travel.

		Frequency	Percent
Valid	Completely disagree	8	5.1
	Disagree	26	16.5
	Neutral	34	21.5
	Agree	63	39.9
	Completely Agree	27	17.1
	Total	158	100.0

The respondents were asked whether they considered that people should decrease their reliance on private vehicles to travel. Table 6.36 shows that 57% of the respondents either agreed or completely agreed that people should decrease their reliance on private vehicles for transport.

6.8.4. Analysis of the relation between the perceptions of vehicle owners and the perceptions of the decrease in the reliance on private vehicles to travel.

This section seeks to define the relation between the perceptions of vehicle owners as discussed in Q6.1 and the perceptions of the decrease in the reliance on private vehicles to travel, presented in Q6.5.

Table 6.37 The perceptions of the vehicle owners on decreasing the reliance on private vehicles.

	Vehicle owner		Total
	No	Yes	
Completely disagree	3	5	8
Disagree	10	16	26
Neutral	9	25	34
Agree	24	39	63
Completely Agree	3	24	27
Total	49	109	158

From Table 6.37 above, we can conclude that the percentages are relatively similar, despite whether a vehicle is owned or not. 58% of the vehicle owners and 55% of the non-vehicle owners agreed and completely agreed with the decreasing reliance on private vehicles.

Q6.6. How can the reliance on private vehicles be decreased?

Table 6.38 The perceptions of the respondents on decreasing the reliance on private vehicles.

Ways of achievement	Completely disagree	Disagree	Neutral	Agree	Completely Agree
Strict control on the import of old and dilapidated cars	2	12	32	81	31
Support and encourage the public transport sector	2	13	33	65	45
Increase the price of consuming fuel	5	13	26	72	42
Increase cost of customs tax for imported cars	6	22	35	72	23

The respondents were asked how a decrease in the reliance on private vehicles could be achieved. As seen in Table 6.38, the significant ways of decreasing the reliance on private vehicles for transportation in the city of Tripoli were ranked according to the perceptions of the respondents as follows:

1. Support and encourage the public transport sector.

2. Increase the price of fuel.

3. Strict control on the import of old and dilapidated cars.

4. Increase the cost of customs tax for imported cars.

6.9. Research question seven: Available options for addressing air pollution caused by motor vehicles in Tripoli.

Q.7. To what extent do you agree or disagree with the available options for addressing air pollution caused by motor vehicles in Tripoli?

Table 6.39 The perceptions of the respondents on the available options for addressing air pollution caused by vehicles in Tripoli

Available options	Completely disagree	Disagree	Neutral	Agree	Completely Agree
Improvement of vehicle technology	3	5	1	60	88
Development of fuel technology.	7	7	32	64	48
Develop of national environmental laws	4	3	11	66	73
Supporting responsible authorities	2	5	19	74	58
Development of the public transport sector.	4	9	11	59	75
Increasing public awareness	6	4	6	65	75
Improving the management of traffic congestion	2	5	21	69	61

As seen in Table 6.39, the most available options for addressing air pollution caused by vehicles were ranked according to the perceptions of the respondents as follows:

1. Improvement in vehicle technology.

2. Increased public awareness.

3. Development of the public transport sector.

4. Development of national environmental laws.

5. Improve the management of traffic congestion.

6. Support responsible authorities.

7. Development of fuel technology.

We can conclude that the appropriate available options show a trend towards vehicle technology, and an increase in environmental awareness.

6.10. Research question eight: Management strategy on air pollution caused by motor vehicles in Tripoli.

This section is divided into two questions; the first question is about the need to develop an environmental strategy to address the problem and the second question was on the technical, institutional, economic and social instruments required to implement the strategy.

Q8.1. To what extent do you agree or disagree that the current status of air pollution from motor vehicles in the city needs the development of an environmental strategy to address the problem and develop effective solutions?

Table 6.40 The perceptions of the respondents on the need for a strategy management for the air pollution caused by vehicles in Tripoli

	Frequency	Percent
Completely disagree	6	3.8
Disagree	7	4.4
Neutral	14	8.9
Agree	60	38.0
Completely Agree	68	43.0
Total	155	98.1

Table 6.40 demonstrates that the respondents who agreed and completely agreed with the need for a management strategy for the air pollution caused by vehicles represented 71% of the total respondents.

The respondents articulated their perceptions of the seriousness of the problem, and the needs for a strategy to address it. This warrants consideration by decision-makers to create an integrated strategy for addressing the problem of air pollution caused by vehicles.

Q8.2. To what extent do you agree or disagree that the strategy needs to provide technical, institutional, economic and social instruments?

Table 6.41 The perceptions of the respondents on the Instruments required for developing a management strategy to combat air pollution caused by vehicles.

	Frequency	Percent
Completely disagree	1	.6
Disagree	3	1.9
Neutral	19	12.0
Agree	72	45.6
Completely Agree	63	39.9
Total	158	100.0

Table 6.41 demonstrates that 85.5% of the respondents either agreed or completely agreed that instruments were required to develop a management strategy for the air pollution caused by vehicles; thus the importance of the provision of such technical instruments is significant for implementing the strategy.

6.11. Chapter Summary

This chapter has reported the findings from a questionnaire which elicited the views and opinions of the respondents about the air pollution caused by motor vehicles in Tripoli. SPSS Software was used for the analysis as this package is one of the ones most commonly applied in the field of Social and Human Sciences.

The questions posed were based on the research questions and objectives, as well as the literature review and secondary sources. A total of 200 questionnaires were distributed to selected respondents, of whom 158 respondents answered all the questions, giving a response rate 79%.

Motor vehicles are the major source of air pollution in the city, which is attributed to the increased vehicle fleet and traffic congestion. Other sources of air pollution, for example, from industries and agricultural activities were given lower responses.

The findings of the analysis showed that the appropriate available options for addressing the air pollution caused by vehicles in Tripoli showed a trend towards vehicle technology, and increased environmental awareness.

The analysis indicated that the majority of the respondents illustrated their belief that there is an urgent need to provide the required instruments to create and implement a strategy on air pollution caused by vehicles in the city of Tripoli, to decrease reliance on private transport. All the evidence gathered from the analysis of the questionnaire, together with the information and data obtained through interviews, will be presented in the next chapter, then further explored and discussed in chapter eight.

Chapter Seven

Analysis of the Interviews

7.1. Introduction

This chapter presents the analysis of the in-depth interviews conducted with ten experts and responsible people from the three concerned institutions; the Environment General Authority (EGA), the GTL (GTL) and the Association of Taxi Drivers (ATD), categorized as shown in Table 7.1.

The interviews included closed and open-ended questions (Appendix2). The selection of these three authorities was based on their tasks related to air pollution caused by motor vehicles.

Table 7.1 Numbers of total interviewees from selected institutions

Authority	Department Manager	Technical staff	Administrator	Total
EGA	2	1	1	4
GTL	Department Manger	Traffic police officer	Traffic administrative	
	1	1	1	3
ATD	Association Manager	Taxi driver		
	1	2		3
			Total	10

The necessary arrangements were made for the interviews and, after many attempts, the interviews were completed during the fieldwork period (July-September 2010).

The ten interviews were conducted in the respondents' offices. Each interview took approximately 50-60 minutes. A digital recorder including photos and video recording were used. In addition, remarks and observations were written in a notebook.

The main aims of these interviews were to obtain information and data as well gather the interviewees' opinions and experiences concerning the air pollution caused by vehicles in Tripoli.

7.2. Data Analysis Procedures

The procedures followed in the analysis of the interviews were in accordance with the following sequence:

i. Codes were selected to present the respondents and their authorities and positions.

ii. The questions were arranged in a sequential form as mentioned in chapter one, followed by sub-questions related to the main research questions.

iii. All of the answers to the questions were presented in the form of tables,

vi. The different answers to each sub-question and the main questions were presented.

v. Conclusions were drawn based on the responses obtained from each institution's respondents to each question.

7.2.1. Coding of the data

The coding of qualitative data is basically the same, as the purpose of coding is to summarize, synthesize, and arrange a lot of observations made of the data. Coding is an essential tool for analysis (John, 1998).

A total of ten interviews were conducted, of which four interviewees represented the EGA, three interviewees the GTL, and three the ATD. The interviewees were coded into three categories: department manager, technical staff and administrator, for each of the three authorities, as shown in Table 7.2 below

Table 7.2 Details of the interview respondents.

Institute .1 EGA	Codes EGA	Institute 2. GTL	Codes GTL	Institute.3 ATD	Codes ATD
Department Managed	R.1(EGA /DM1	Department Managed	R.1 (GTL /DM1)	Association Manager. 1	R.1 (ATD / AM1
Department Manager 2.	R.2(EGA /DM2	Traffic Officer.1	R.2 (GTL /T01)	Taxi driverl	R.2 (ATD /DR1)
Technical Staff. 1	R.3(EGA / TS1)	Traffic Officer. 2	R.3 (GTL / T02)	Taxi driver2	R.3 (ATD / DR2)
Administrative 1	R.4(EGA /AD1)				

7.2.2. Data analysis

All of the data obtained from the interviews were transferred into a Microsoft excel programme for the purpose of sorting and grouping.

The analysis involved the following stages:

i. Re-reading the interview transcripts and writing down many headlines in order to describe all aspects of the content.

ii. Filtering out subjects not related to the research topic.

iii. Categorizing the interview dialogue, including almost all of the interview data. This stage is called ‘open coding’. Categories are freely generated at this stage.

iv. Collapsing similar headlines into broader categories in order to reduce the number of categories

v. In the last stage, the interview contents were categorized into eight groups of categories as shown below:

1. Air quality status in Tripoli city.
2. Air pollution caused by motor vehicles in Tripoli city.
3. Factors affecting traffic air pollution in Tripoli city
4. Effects of air pollution caused by motor vehicles in Tripoli
5. The actions taken and relevant policies to manage traffic air pollution.
6. Reliance on private vehicles to travel in Tripoli city.
7. Available options for reducing traffic air pollution in Tripoli city.
8. Management strategies for reducing traffic air pollution in Tripoli city.

The groups of questions were presented to the respondents according to the categories mentioned above and the answers obtained from the respondents. A qualitative analysis of these responses is also presented as follows:

7.3. Research question one: Air quality status in Tripoli city

How do you describe the status of air quality in Tripoli and what are the main sources that may cause air pollution in the city?

7.3.1. Air quality in Tripoli and the required criteria

Do you consider that the air quality in Tripoli meets the required criteria?

The respondents were asked whether they considered that the air quality in Tripoli met the required criteria. Most of the respondents believed that the air quality in the city has been damaged but the actual evaluation of the air quality in the city currently is impossible due to the lack of information and data, as can see in Table 7.3, where the responses are summarized.

Table 7.3 The perceptions of the respondents to the air quality status in Tripoli

EGA Respondents	Respondent. 1 (EGA/DM1)	Air quality data were unavailable and there is no continuous monitoring of air quality in Tripoli due to the lack of a monitoring system in the city.
	Respondent.2 (EGA/DM2)	The evaluation of the status of air quality in Tripoli is impossible due to lack of required data about the scale of pollutants from different sources.
	Respondent.3 (EGA/ TS1)	The atmospheric air in the city of Tripoli is subjected to many air pollutants that affect its quality, as can be noted clearly during the summer season.
	Respondent .4 (EGA/AD 1).	The climate of the city helps to transport air pollutants away from the areas of traffic and so the air quality is not unsuitable.
GTL Respondents	Respondent. 1 (GTL/DM1).	The air pollution in Tripoli is acceptable as there is no considerable pollution emitted from vehicles in Tripoli
	Respondent .2 (GTL /T01).	In Tripoli city, the air quality is damaged as about one million vehicles use the road network.
	Respondent .3 (GTL/TA1).	There is a problem of air quality which is damaged by pollution from land transport as many vehicles travel in Tripoli, most of them private vehicles.

7.3.2. The main sources of air pollution in Tripoli

What are the main sources of the air pollution in Tripoli?

The EGA interviewees were asked about the major sources of air pollution in Tripoli. As seen in Table 7.4 below, most of the respondents from the EGA indicated that the major sources of air pollution in Tripoli are motor vehicles, waste disposal and plant power generation as well as light manufacturing, such as the smelting operations of heavy metals.

Table 7.4 The perceptions of the respondents about the sources of air pollution in the city of Tripoli.

EGA Respondents

Respondent. 1 (EGA/DM 1)

Land transport can be considered the main source of air pollution in Tripoli, along with domestic waste disposal and small manufacturers and other human activities.

Respondent.2 (EGA/DM2)

The major source of air pollution in Tripoli is land transport and there is light manufacturing, such as heavy metals smelting and the burning of household waste.

Respondent.3 (EGA/TS1)

The power generation plant and increased vehicle fleet can be considered the major sources of air pollution and also the burning of medical waste.

Respondent.4 (EGA/AD1)

EGA has no reports or environmental surveys. Some indications confirmed that motor vehicles are the biggest source, as is the existence of light industries in the city.

7.4. Research question two: contribution of motor vehicles to air pollution

How does the use of motor vehicles contribute to air pollution?

The EGA interviewees were asked how the use of motor vehicles contributes to air pollution. As seen in Table 7.5 below, most of those interviewees pointed out that cars make a large contribution to urban air pollution as the kind of fuel consumed in vehicle engines in Tripoli produces harmful pollutants which can damage the air quality. Moreover, the number of vehicles in Tripoli has increased, which has greatly contributed to the city's air pollution problem.

Table 7.5.The perceptions of interviewees on the contribution of motor vehicles to air pollution in Tripoli.

EGA Respondents
Respondent. 1 (EGA/DM1) Vehicles using petrol and diesel fuel produce many pollutants which can affect the air quality and damage health and the environment.
Respondent.2 (EGA/DM2) The contribution of vehicles to air pollution is through the combustion of fuels in different vehicle engines which produce large amounts of harmful gases.
Respondent.3 (EGA/TS1) Fuel combustion in car engines results in different kinds of emissions that affect air quality as these materials have the potential to damage the air quality
Respondent .4 (EGA/AD1) There are too many vehicles in Tripoli and they emit pollutants which can damage the air quality. The vehicles in Tripoli should be considered as the main contributors to the air pollution problem in the city

7.5. Research question three: Air pollution caused by motor vehicles in Tripoli

To what extent does traffic air pollution occur in Tripoli and what are factors that have led to this environmental problem?

7.5.1. Air pollution caused by motor vehicles

Do you consider that vehicles cause air pollution problems in the city?

The interviewees were asked if they considered that the vehicles caused air pollution problems in the city. As seen in Table 7.6 below, Tripoli suffers from a problem of air pollution from cars as there has been an increase in the vehicle fleet and hence in the quantities of fuel consumed. However, due to an absence of data, it is impossible to confirm the scale of traffic air pollution in the city of

Tripoli. Respondents 3 (from GTL) and 4 (from EGA) believed that the traffic air pollution in Tripoli in not too significant.

Table 7.6 The perceptions of the interviewees on air pollution caused by motor vehicles in Tripoli city.

EGA Respondents	Respondent. 1 (EGA/DM 1)	Tripoli is subject to air pollution from vehicles as a result of the increase in vehicle numbers in the city but no data are available to confirm the extent of this pollution.
	Respondent.2 (EGA/DM2)	The increase in motor vehicles which has led to the increased severity of traffic congestion, that consequently results in emission of higher quantities of air pollutants in the city.
	Respondent.3 (EGA/ TS1)	There has been a significant increase in the number of imported vehicles in the past few years. Also, the quantities of fuel consumed are too large and that has produced a traffic air pollution problem in Tripoli.
	Respondent .4 (EGA/AD 1)	Air pollution caused by land transportation occurs in Tripoli but it is not at a higher rate, where Tripoli is an open area; therefore air pollution by vehicles can be considered not to have risen
GTL Respondents	Respondent. 1 (GTL/DM1)	Air pollution from vehicles has occurred in Tripoli for many years due to an increase in the vehicle fleet but, in recent years, it may be less.
	Respondent .2 (GTL /T01)	It is clear from the increase in the annual vehicle fleet and traffic congestion on most of road networks in the city that there is a problem of air pollution from cars.
	Respondent.3 (GTL/TA1)	The pollution from cars in the city of Tripoli is not too significant, in spite of an increase in the level of car traffic congestion because most of the vehicles are new in the last five years.

7.5.2. Factors affecting traffic air pollution in Tripoli

What are the affecting factors that have led to air pollution caused by vehicles in Tripoli?

The EGA interviewees were asked about the affecting factors that have led to air pollution caused by vehicles in Tripoli. As seen in Table 7.7 below, the majority of the respondents stated that the main significant factors are the increase in the vehicle fleet, the types and quantities of fuel consumed, development of the economy, increased population growth, lack of public transport, weakness of environmental legislation on the control of air quality, lack of public awareness about traffic air pollution and severity of traffic congestion on the road network.

Table 7.7 The perceptions of interviewees on the factors affecting traffic air pollution

EGA Respondents
Respondent. 1 (EGA/DM 1)
The most affecting factors are the increase in the vehicle fleet, lack of public transport, polluted fuel as well as weakness of the environmental legislation and lack of environmental public awareness
Respondent.2 (EGA/DM2)
Growth of the population and economy, increase of private vehicles, lack of compliance with environmental law as well as the lack of a public transport infrastructure.
Respondent.3 (EGA/ TS1).
Increase in the population and private vehicles, weakness of the infrastructure of public transport as well as vehicle engine conditions, weakness of air quality control legislation.
Respondent .4 (EGA/AD1).
Increase in personal vehicles, increase in population and development of the economy, non-implementation of environmental law and lack of public transport as well as severity of traffic congestion.

7.6. Research question four: Effects of air pollution caused by motor vehicles in Tripoli.

How is air pollution caused by motor vehicles relevant to health, the environment and economic matters?

7.6.1. The Health effects

Do you think that there are health impacts as a result of exposure to air pollution emitted from vehicles in Tripoli?

The respondents were asked if they thought that there are health impacts resulting from exposure to air pollution emitted by vehicles in Tripoli. As seen in table 7.8 below, they suggested that the inhalation of air pollution emitted from vehicles may be linked to all kinds of diseases, such as respiratory diseases. These may or may not be caused by exposure to pollution, but this cannot be confirmed as no data or information are available in Tripoli about the kinds and numbers of diseases that may result from air pollution in the study area.

Table 7.8 The perceptions of the interviewees on the health effects of traffic air pollution

EGA Respondents
Respondent. 1 (EGA/DM 1) Due to a lack of such information and data in Tripoli, an evaluation of the health effects of traffic air pollution is unavailable. This area needs studies and field surveys.
Respondent.2 (EGA/DM2) Some data issued by a Central Hospital of Chest Diseases may relate to air pollution but needs investigating to determine the relationship between these diseases and exposure to traffic air pollution
Respondent.3 (EGA/ TS1) It is difficult to determine the health effects in the absence of data about the kinds of air pollutants present. In fact, no information is available concerning the extent of the effects on health resulting from air pollution emitted by vehicles
Respondent .4 (EGA/AD1) Exposure to air pollution caused by vehicles must result in health effects and many diseases occur. This could be happening in Tripoli as air pollution is expected to be occurring.

7.6.2. Environmental effects

Do *you think that there are environmental impacts as a result of exposure to air pollution emitted from vehicles in Tripoli?*

The respondents from EGA were asked if they thought that there are environmental impacts resulting from exposure to air pollution emitted from vehicles in Tripoli. As seen in Table 7.9 below, the majority of respondents mentioned that, as a result of exposure to air pollution, effects on the environment, including impacts on plants, water resources, vegetation and biodiversity, may occur in Tripoli, as well as climate change. There may also be damage to materials and buildings. However, an evaluation of the extent of these environmental effects of traffic air pollution is impossible, as no relevant studies have been conducted.

Table 7.9 The perceptions of the interviewees on the environmental effects of traffic air pollution

EGA Respondents
Respondent. 1 (EGA/DM1) The environmental effects need to be investigated by field surveys to provide information, as no data are available at all due to a lack of studies and researches concerning these environmental effects.
Respondent.2 (EGA/DM2) Some areas in Tripoli are subjected to environmental effects where the plants have been damaged due to exposure to air pollution. EGA has not carried out any surveys or field studies about such effects.
Respondent.3 (EGA/ TS1) There is an association between exposure to air pollution and the effects on the environment, such as negative impacts on ecosystems and natural resources, including water, soil, food and archaeological buildings.
Respondent .4 (EGA/AD1) The environmental effects observed in Tripoli included black smoke appearing on some buildings in the city, which was thought to be a result of air pollution caused by vehicles.

7.6.3. Economic effects.

Are there economic impacts resulting from air pollution caused by vehicles in Tripoli?

The respondents were asked about the economic impacts resulting from air pollution caused by vehicles in Tripoli. As seen in Table 7.10 below, traffic air pollution was thought to have economic effects, as the restoring the situation to its natural status before the damage requires a lot of money, particularly for the treatment of diseases and to rebuild the environmental resources that have been destroyed. The evaluation and calculations of the economic effects need a survey and the collection of data about all of the damage from air pollution, which is unavailable from EGA yet.

Table 7.10 The perceptions of interviewees on the economic effects of traffic air pollution

EGA Respondents
Respondent. 1 (EGA/DM1) The economic effects include the money needed to treat and solve the damages and risks associated with air pollution caused by vehicles, such as the treatment of disease and rebuilding of the environmental resources that have already been destroyed by air pollution.
Respondent.2 (EGA/DM2) The return of the environment ecosystem to its essential status before being damaged by traffic air pollution needs extra funds, but the evaluation of these economic effects is not available yet.
Respondent.3 (EGA/TS1) The resolution of the problem, including the threat of health effects and damage to the environmental ecosystem, needs a lot of money. There is no evidence about the value of the economic effects of traffic air pollution
Respondent .4 (EGA/AD1) It was difficult to assess the economic effects in previous years. A survey and data are required about all the kinds of damage to health, the environment and society.

7.7. Research questions Five: The actions taken and relevant policies to address the air pollution caused by vehicles in Tripoli.

What actions have been taken to reduce traffic air pollution? Are there any policies, plans, legislation and programmes relevant to addressing the problem of air pollution caused by vehicles in Tripoli?

7.7.1. The role of the EGA in reducing air pollution caused by motor vehicles in Tripoli.

What are the roles of EGA in terms of reducing air pollution caused by vehicles? Do you think that EGA has the required technical capability to address the issue of air pollution caused by vehicles? If no, what are the obstacles to this?

The respondents from EGA were asked about the roles of EGA in terms of reducing air pollution caused by vehicles. As shown in Table 7.11 below, EGA is a higher institution that has been responsible for environmental protection since it was established in 1999. The roles of EGA in terms of air quality include taking measurements of air pollutants, providing technical reports about air quality issues, training technical staff, undertaking a survey of the sources of air pollution and proposing air quality management plans as well as increasing public awareness about air quality issues. EGA has a Department of Control and Protection of the Environment from Pollution, which is one of its technical departments. EGA lacks the ability to fulfil most of its tasks due to a lack of required instruments, including qualified people and equipment.

Table 7.11 The perceptions of the interviewees on the role of the EGA.

EGA Respondents
Respondent. 1 (EGA/DM 1) EGA is the higher institute authorized to control the sources of air pollution and propose plans and projects to prevent air quality from pollution; EGA's structure includes the Department for the Control and Protection of the Environment from Pollution.
Respondent.2 (EGA/DM2) EGA's roles in terms of air quality issues were mentioned in environmental law no 15; 2003.The Laboratories Affairs Department has a section called the laboratories Section which contains a unit on air pollution.
Respondent.3 (EGA/ TS1) The tasks of EGA include measuring air pollution concentration, proposing plans, projects and action plans to protect the environmental resources and raise public awareness of environment issues.EGA has no ability to do most of these tasks due to a lack of financial support.
Respondent .4 (EGA/AD1) The role of EGA involves the protection of air quality from all sources. These tasks include proposing an action plan to protect air quality, and also issuing permits for projects that may emit air pollutants.EGA staff's capability to do so is limited.

7.7.1.1. Technical facilities for air quality control.

Do *you have the potential technical, human and financial resources to control and manage traffic air pollution and resolve the problem?*

The respondents from EGA asked if they had the potential technical, human and financial resources to control and manage traffic air pollution and resolve the problem. As shown in Table 7.12 below, the Government has not paid attention to the protection of the environment, including the issues of air quality monitoring during the past few years, and so did not provide the required support for EGA to have the necessary equipment to measure air pollutants and monitor air quality in the city. Therefore, EGA lacks resources. An air quality monitoring system is unavailable and the technical staff were not qualified to undertake this in the absence of concentrated training and higher education in the field of air pollution studies.

Table 7.12 The perceptions of the interviewees regarding the technical facilities of the EGA authority for air quality control.

EGA Respondents
Respondent. 1 (EGA/DM 1) Human resources are limited as EGA suffers from a shortage of human resources as there are no qualified people with high skills in air quality control and management plus the lack of required equipment and instruments.
Respondent.2 (EGA/DM2) There are equipment and devices that were imported in 1997 that, for administrative and technical reasons, were not installed. In 2010, EGA imported a mobile lab for air pollutant measurements; EGA still needs more support to improve its capability.
Respondent.3 (EGA/TS1) The human and instrumental resources of EGA are limited. The experts and necessary equipment to control and measure the air quality levels are unavailable and there is a lack of an air quality monitoring system.
Respondent.4 (EGA/AD1) The government does not provide enough support for EGA in order to improve its potential technical and human resources for addressing air pollution caused by vehicles.

7.7.1.2. Measurement of vehicle emissions.

Does the EGA conduct the regular measurement of air pollutants emitted by vehicles? If so, what are the measured pollutants? If no, what are the obstacles to this?

Respondents from EGA were asked about the measurement of vehicle emissions. As seen in Table 7.13 below, there was no measurement of air pollutants including the pollutants emitted by cars in previous periods because of the lack of equipment and instruments needed to take such measurements. EGA lacked such equipment, and some equipment was simply stored in the laboratories without installation or calibration, EGA had never dealt with traffic air pollutant measurements and had only recently started to conduct such measurements in 2010.

Table 7.13 The perceptions of the interviewees on the measurements of vehicle emissions in the city of Tripoli.

EGA Respondents

Respondent. 1 (EGA/DM 1)

No air pollutant measurements have been made due to a lack of equipment and devices. This year (2010), EGA provided a mobile lab for measuring air pollutants. We started this work in July 2010.

Respondent.2 (EGA/DM2)

There was no possibility of having emissions measurements due to a lack of equipment in the past few years, including pollutants emitted by vehicles, and the absence of a dedicated team.

Respondent.3 (EGA/ TS1)

Vehicular emissions measurements were never done in previous years because of a lack of facilities such as the devices needed to measure the air pollutants.

Respondent .4 (EGA/AD1)

Despite the availability of some equipment stored in EGA storage, no kind of emissions measurement has been taken, including the air pollutants emitted by vehicles and only this year (2010) has EGA started to take some measurements.

7.7.1.3. The Obstacles and difficulties facing EGA

What are the main difficulties and obstacles facing EGA in terms of addressing air pollution problem caused by vehicles?

The interviewees were asked about the main difficulties and obstacles that EGA has faced in terms of addressing the air pollution problem caused by vehicles. As seen in Table 7.14, the interviewees from EGA pointed out that the difficulties facing EGA include financial and technical aspects. EGA suffers from a lack of financial support from the government for the implementation of projects on various environmental issues, and also lacks specialists and experts in the field of studies of air pollution from vehicles. Also, it suffers from severe shortages of equipment for the measurement, analysis and monitoring of air quality, which made it unable to create and implement programmes and plans to address traffic air pollution issues.

Table 7.14 The perceptions of the interviewees on the obstacles and difficulties facing EGA.

EGA Respondents
Respondent. 1 (EGA/DM1) EGA faces many difficulties including a lack of the necessary financial support to implement its proposals for environment protection. There is also a weakness with regard to the training and qualifying of technicians in the field of air quality control and studies of traffic air pollution.
Respondent.2 (EGA/DM2) EGA does not have expertise in the field of studies of pollution. In addition, being structured under the Ministry of Medicine, EGA is unable to exercise its supervisory role due to the higher authorities in the government.
Respondent.3 (EGA/ TS1) The government does not provide financial support for EGA to conduct specialized studies in the field of air quality. The technical capabilities and human resources are limited.
Respondent .4 (EGA/AD1) EGA suffers from the problem of non-compliance by institutions and individuals to its instructions and recommendations, thus making it unable to impose its recommendations on other ministries. The obstacles include a shortage of human resources.

7.7.2. The Role of the GTL

What are the roles of the GTL in addressing the problem of traffic air pollution in the city?

The GTL interviewees were asked about the role of the GTL in addressing the problem of traffic air pollution in the city. As seen in Table 7.15, the GTL is charged with the implementation of the traffic law and managing the traffic on the road network. In addition, it conducts the procedures regarding the issue of vehicle licences, as well as following up the procedures of vehicle registration.

Table 7.15 The perceptions of the interviewees on the roles of GTL

GTL Respondents
Respondent. 1 (GTL/DM1) The role played by GTL includes the management of traffic on the roads, the issuing of driver licences and undertaking a technical inspection of vehicles. It also pursues the implementation of the traffic law
Respondent .2 (GTL /T01) GTL is responsible for executing the articles of traffic law no 11/1984; it also manages the traffic congestion on the road network as well as issuing driving licences for vehicles, including motor vehicle registration.
Respondent .3 (GTL /TA1) The role of GTL in terms of traffic air pollution is limited. It involves only traffic management and conducting technical conditions for issuing driving licences, which focus on vehicle safety. GTL is responsible for vehicle registration.

7.7.2.1. The resources and capabilities provided for GTL

Does GTL have the capability to implement its tasks in terms of addressing the traffic air pollution problem in the city? If not, what are the difficulties faced in this regard?

The GTL interviewees were asked whether GTL has the capability to implement its tasks in terms of addressing traffic air pollution problem in the city. As seen in Table 7.16 below, the number of traffic police is not enough to cover all roads networks in the city and they are not adequately qualified for traffic management. In the absence of training programmes, GTL does not have the electronic equipment to monitor and regulate the traffic on the roads and there is no equipment to conduct vehicle engine tests.

Table 7.16 The perceptions of the interviewees on GTL's capabilities.

GTL Respondents
Respondent. 1 (GTL/DM1) The number of police traffic is insufficient and most traffic police lack capability due to a lack of training, inadequate financial resources and the lack of provision of instruments and equipment needed for traffic management.
Respondent.2 (GTL /T01) The facilities of GTL are limited. They do not have the equipment to monitor and regulate the traffic on the roads; there is no equipment to check the engines of motor vehicles.
Respondent.3 (GTL /TA1) Traffic Police in the city do their work without intensive training and also they do not have enough information about environmental issues, including traffic air pollution.

7.7.2.2. Inspection and testing of vehicle engines

Are vehicles subject to technical inspection to detect the efficiency of engine performance? If the answer is no, will you achieve this in the future?

The GTL interviewees were asked whether vehicles are subjected to a technical inspection to detect the efficiency of engine performance and, if not, will this be achieved in the future?

As seen in Table 7.17 below, a technical inspection of motor vehicles is not conducted. Legally, such inspections are not required for the issuing of vehicle licences. Currently, as in past years GTL, has not dealt with vehicle engine tests as a required condition for licensing because the instruments and equipment needed were unavailable, GTL would like to have such technical inspections as this would help to control vehicle emissions and they hope to conduct such tests in the near future.

Table 7.17 The perceptions of the interviewees on the technical inspection of motor vehicles.

GTL Respondents

Respondent. 1 (GTL/DM1)

Engine testing is not carried out by GTL due to a lack of instruments and equipment. EGA does not require GTL to deal with these tests and investigations.

Respondent.2 (GTL /T01)

GTL did not deal with vehicle engines in the past year or now, GTL wishes to have such technical inspections as they will help to control vehicle emissions.

Respondent.3 (GTL /TA1)

No such vehicle engine tests and investigation are undertaken by GTL as that is not required by the traffic law, as well due to the lack of capabilities to undertake such tests.

7.7.2.3. Management of Traffic congestion

Is there a traffic management system to facilitate traffic congestion on the road network in Tripoli? If not, will you have one in the future?

The interviewees were asked whether there is a traffic management system to facilitate traffic congestion on the network roads in Tripoli and, if not, whether there will be one in the future. As seen in Table 7.18 below, the management of traffic congestion is carried out in the absence of technology and advanced control, such as TV cameras and satellite. The institute lacks such systems and they manage the traffic on the road network based on traffic lights and manually. GTL wishes to have the new instruments needed for traffic management.

Table 7.18 The perceptions of the interviewees on the traffic management system

GTL Respondents
Respondent. 1 (GTL/DM1) The management of traffic on the roads is through traffic lights and radio communications, GTL do not have electronic systems on the roads and there is also a lack of a satellite monitoring system.
Respondent.2 (GTL /T01) The management of traffic on the road network is mostly done by traffic police and traffic lights due to the lack of new technology for traffic management.
Respondent .3 (GTL /TA1) GTL has no advanced techniques or systems for managing the traffic on the road network, GTL supports any actions to improve the instruments used for traffic management

7.7.2.4. The obstacles and difficulties facing GTL

What are the main difficulties and obstacles facing GTL in terms of contribution towards addressing the air pollution problem caused by vehicles?

The interviewees from GTL were asked about the main difficulties and obstacles that have faced GTL in terms of the contribution to addressing the air pollution problem caused by vehicles. As seen in Table 7.19, GTL suffers from many difficulties, including those related to the lack of financial support, instruments and equipment needed for the work. This includes a lack of technology to control and manage the movement of vehicles on the road network, as well as the inability of the traffic police to conduct technical inspections of vehicle engines to determine the amount of pollutants emitted by cars, since no training or devices are provided. The traffic police do not receive workshops on air pollution from cars.

Table 7.19 The perceptions of the interviewees on the obstacles and difficulties facing GTL

GTL Respondents
Respondent. 1 (GTL/DM1) GTL suffers from a lack of financial support. It does not have the equipment necessary to perform its tasks, such as an electronic system for controlling traffic congestion.
Respondent .2 (GTL /T01) A lack of devices for the better management of traffic congestion. Also, the inability to conduct vehicle engine tests because of a lack of specialists and equipment to do so.
Respondent.3 (GTL /TA1) The main obstacles are a lack of electronic management system and lack of financial support. The GTL is not an independent institute and has no independent financial sections. Also, most traffic police have no long term training.

7.7.3. The environmental law and relevant regulations.

Does environmental legislation have the ability to control and protect the air quality from road transport pollution?

The interviewees were asked about the ability of the environmental legislation to control and protect air quality from road transport pollution. As seen in Table 7.20, there is no national law on air quality in Libya. Environmental Protection act 7, issued in 1982 and amended by act 15, 2003, covers all environmental issues, including the protection of atmospheric air quality. However, the act suffers from some weaknesses in the articles on the control of air quality. The national environmental legislation has no significant ability to treat the issues of traffic air pollution, particularly in the absence of a specific law on air quality issues.

Table 7.20 The perceptions of the interviewees on the environmental law and relevant regulations.

EGA Respondents
Respondent. 1 (EGA/DM1) Environmental Protection Act No. 15 of 2003 it is an amended edition of act No. 7 of 1982. It is the only national law concerning environmental protection, including the protection of atmospheric air. The act suffers from several weaknesses in terms of its articles on the control of air quality, which need to be amended.
Respondent.2 (EGA/DM2) Traffic air pollution is included in national environmental law 15/2003, but the national environmental laws were unable to cover all issues relating to traffic air pollution due to the lack of required details about vehicular emissions.
Respondent.3 (EGA/ TS1) There is no special law on air quality issues. National environmental act15, 2003 covers all environmental issues including air quality, but the law still needs more development in terms of air quality issues.
Respondent .4 (EGA/AD1) Act 15, 2003 includes a special chapter on the atmosphere, but there is no special national law on air quality in Libya. Environmental law no 15, 2003 does not pay enough attention to the issue of air pollution from cars, and it is considered as unable to cover issues of traffic air pollution.

7.7.3.1. National environmental legislation and vehicle engine efficiency

Do *the environmental legislation and traffic law deal with the technical investigation into the* efficiency of *vehicle engines?*

The respondents from EGA and GTL were asked whether the environmental legislation and traffic law cover the technical inspection of the efficiency of vehicle engines. As shown in Table 7.21 below, Environmental Protection Act

No. 15 of 2003 requires the conducting of vehicle engine tests but actually no technical tests on the efficiency of automobile engines are carried out by either GTL or EGA, as these tests are not required as a condition for issuing vehicle licences. The reasons given for the failure to carry out such tests were the lack of required devices and/or technicians qualified to undertake them.

Table 7.21 The perceptions of the interviewees of the vehicle engine test.

EGA Respondents	Respondent. 1 (EGA/DM1)	Environmental Protection Act No. 15/2003 requires vehicle engine tests but EGA does not conduct such tests. Also, it does not carry out maintenance or periodic inspections of motor vehicles due to a lack of equipment needed to conduct tests and qualified people as well.
	Respondent.2 (EGA/DM2)	This test is the prerogative of the GTL but it does not conduct tests on motor vehicle engines, perhaps because of a lack of the required devices and traffic police technicians.
	Respondent.3 (EGA/ TS1)	Vehicle engine testing has never been done before. It’s not required for issuing vehicles licences, although it is required by environmental law.
	Respondent .4 (EGA/AD1).	Such tests were not requested by the Department of Traffic Police, who are unable to do so due to a lack of equipment and technical staff to undertake such vehicle engines tests.
GTL Respondents	Respondent. 1 (GTL/DM1).	The actions carried out by the Traffic Department to issue vehicle licences do not include vehicle engine tests or the investigation of engine efficacy.
	Respondent .2 (GTL /T01).	GTL has never dealt with vehicle engine tests and does not have a specialized department to conduct these tests, as they do not have the equipment or people who are able to carry out these tests.
	Respondent .3 (GTL/TA1).	EGA has never required the Traffic Administration to conduct such engine tests and did not provide the required equipment or offer training for GTL staff to be able to perform such tests.

7.7.3.2. Law of Traffic on the roads

Is the Traffic Act able to manage the traffic congestion and control vehicles that may emit air pollution in the city?

The GTL interviewees were asked whether the Traffic Act is able to manage the traffic congestion and control for vehicles that may emit air pollution in the city. As seen in Table 7.22 below, the Traffic Act was issued in 1984, which is some time ago now, but the respondents considered it quite suitable for covering all aspects relating to traffic on the road network; it only needed to be developed in order to keep pace with developments in this area by revising certain articles and adding new one about the control of emissions from vehicles, including the testing of vehicle engines.

Table 7.22 The perceptions of interviewees on the Traffic Act.

ATD Respondents	Respondent. 1 (ATD /DMI)	The current traffic law is appropriate for managing traffic congestion and it is unnecessary to include articles concerning the protection of the environment.
	Respondent.2 (ATD /DRI)	The Traffic law was issued in 1984 but was not implemented correctly. The lack of commitment, instruments and equipment in the law articles have led to the non-implementation of the law.
	Respondent.3 (ATD /DR2)	The Traffic law is not suitable nowadays as the law was issued a long time ago and missed a lot of aspects relating to traffic. The traffic law needs to be developed
GTL Respondents	Respondent. 1 (GTL/DM1).	The national traffic law was issued in 1984 and it is quite suitable for traffic issues but still needs amending as it was issued a long time ago and needs to include some new aspects regarding the air pollution caused by vehicles.
	Respondent .2 (GTL /T01).	It is quite good in terms of managing all the issues relating to traffic on the roads. It is just necessary to revise some of the articles and add new articles about controlling emissions by vehicles, including testing the vehicle engines
	Respondent .3 (GTL/TA1).	The Traffic law includes all aspects of traffic on the road network and it only needs to be developed in order to be fit for the developments that have happened in this area.

7.7.4. Actions taken to reduce the air pollution caused by motor vehicles

Have any actions been taken in the past to reduce the problem of air pollution from cars in the study area? If the answer is yes, what are these procedures?

The respondents were asked whether any actions have been taken in the past to reduce the problem of air pollution from cars in the study area and, if so, what? As seen in Table 7.23 below, it was reported that irregular steps have been taken but these did not adequately address the problem of traffic air pollution. These actions included an amendment to the environment law, the issuing of conditions for the import of cars, improvements in the road network and the abolition of petrol leaded fuel. The effects of these actions are very limited and have had no impact on reducing traffic air pollution.

Table 7.23 The perceptions of the interviewees on the actions taken to address the problem

EGA Respondents	Respondent. 1 (EGA/DM 1)	The actions included the amendments to Law No.7 of 1982 on the protection of the environment, the issuing of conditions relating to imported cars, and also the phasing out of leaded petrol and building the second stage of the ring road to decrease traffic congestion.
	Respondent.2 (EGA/DM2)	The actions taken included phasing out the use of leaded petrol, amendment of the national environmental law, and purchase of equipment for the measurement and analysis of air pollutants but, for administrative reasons, these have not been used in previous years.
	Respondent.3 (EGA/TS1)	The actions were not large and had little impact on reducing traffic air pollution. Some measures were taken, such as stopping the use of leaded fuels and also developing the environment law and EGA structure.
	Respondent .4 (EGA/AD 1).	Provided support for the creation of public transport companies as well as the establishment of the second stage of the ring road. In addition, developing the capacity of the EGA technical staff.
	Respondent. 1	The actions included the issuance of a

	(GTL/DM1).	decision by the Minister of Public Security to stop cars which may emit thick smoke from using the road network. Also, the owner's driving licence would be revoked and the owner would be fined.
GTL Respondents	Respondent .2 (GTL /T01).	Issuance of a decision about importing cars as well as some measures concerning the management of traffic on the roads, such as re-planning the entrance and exit roads of the city.
	Respondent .3 (GTL/TA1).	Preventing private cars from entering the city centre, but this was later cancelled because of complaints by the owners of the commercial market in the city centre. Also reducing the duration of the vehicle licences provided for old models of vehicles.

7.7.5. Policies and programmes available to reduce air pollution caused by motor vehicles

Do you have plans and programmes for reducing traffic air pollution in the city? If yes, what are the main elements involved? If no, do you have future projects related to this topic?

The respondents were asked if they had any plans and programmes for reducing traffic air pollution in the city and, if so, what were the main elements involved. If the answer was no, did they have future projects of interest in this area. As seen in Table 7.24 below, there was a national programme for the improvement of the environment 2006 - 2011, which included a number of projects, including one to monitor and control air quality, but the government did not provide financial support for its implementation. The air quality project included the establishment of ten fixed monitoring stations for locations in the coastal area of the country.

Table 7.24 The perceptions of the interviewees on the relevant policies for managing traffic air pollution in Tripoli.

EGA Respondents
Respondent. 1 (EGA/DM1) EGA has already issued a project for an environmental protection plan 2006-2011. This project included a sub-project for air quality but no financial budget was provided to execute this project.
Respondent.2 (EGA/DM2) EGA proposed a national environmental project for environmental improvement in 2005 which involved many issues including air quality monitoring and air pollution emitted from cars.
Respondent.3 (EGA/TS1) There are no plans and strategies concerning environmental issues except for a proposal for environmental protection that was issued in 2005 called the National Programme for Environmental Improvement 2006-2011.Air quality control was part of this project, along with other environmental issues.
Respondent .4 (EGA/AD1) EGA proposed in 2005 a national programme to improve the environmental status at a cost of 900 million Libyan dinars. It included a number of projects, including air quality.

7.8. Research question Six: decreasing the reliance on private transport in the city

Why should people decrease their reliance on private vehicles to travel? And how can that be achieved?

7.8.1. Decreased reliance on private transport for travel.

Why should people reduce their reliance on private vehicles?

The respondents were asked why people should reduce their reliance on private vehicles. As seen in Table 7.25 below, a reduction in the reliance on the use of private cars and the trend towards the use of public transport were assumed to play a significant role in terms of reducing traffic air pollution. A decreased reliance on private vehicles for transport would reduce the quantities of fuel consumed, ease traffic congestion and as result reduce the total amount of emissions from vehicles, People should rethink their reliance on their own vehicles and change private transport by reducing their use of private vehicles for travel.

Table 7.25 The perceptions of the interviewees on the decreased reliance on private transport

EGA Respondents	Respondent. 1 (EGA/DM 1)	The decreased reliance on the use of private transport would save large quantities of fuel consumption, lead to less traffic congestion and as a result of that reduce the amounts of total emissions from vehicles.
	Respondent.2 (EGA/DM2)	The reduced reliance on the use of private cars and the trend towards the use of public transport would play a significant role in terms of reducing the emissions from vehicles.
	Respondent.3 (EGA/ TS1)	People have to rethink the use of their own vehicle and they should change their behaviour in dealing with the means of private transport because that will contribute towards saving energy, reducing pollution and saving money as well as improving air quality.
	Respondent .4 (EGA/AD 1)	The continued use of private cars would significantly increase the amount of fuel used and increase the severity of the traffic congestion on the roads, which contributes to increased quantities of air pollutants emitted by cars.
GTL Respondents	Respondent. 1 (GTL/DM1)	People should reduce their dependence on private transportation because it causes a lot of problems, such as traffic congestion, a large number of accidents and also the destruction of the road network.
	Respondent .2 (GTL /T01).	Reducing the number of private cars will contribute to the flow of traffic and thus improve the ease of access to work and school on time and contribute towards reducing pollution.
	Respondent .3 (GTL/TA1).	Increasing the number of private cars has led to the growing problem of traffic congestion on the roads and increased the number of traffic incidents, which has had an economic impact,

		also increases pollution.
ATD Respondents	Respondent. 1 (ATD / DMI)	Reducing the citizens' reliance on private cars will contribute to the development of the public transport sector, which will have several positive aspects, including reducing pollution, and reducing traffic congestion.
	Respondent.2 (ATD /DRI)	Reducing the reliance on private vehicles will influence the amount of traffic on the roads. This is necessary because it would contribute to the increased activity of the public transport sector and reduce traffic congestion.
	Respondent.3 (ATD / DR2)	People must decrease the use of private cars for obtaining their daily necessities and transfer towards the use of public transport, such as taxis, in order to contribute to solving the problem of environmental pollution.

7.8.2. Achievement of a decreased reliance on private transport for travel

How would the growth of private transport be achieved?

The respondents were asked how the decrease in private transport could be achieved. As seen in Table 7.26 below, the most significant measures for reducing the reliance on private transport in the city were thought to be dealing with the causes that have led to the increase in the number of private vehicles, including the development of technical requirements for importing cars, raising customs taxes on imported cars, increasing the price of fuel and preventing the importation of old vehicles, as well as the development of public transport, to provide good quality services to all areas in the city. There is a need to focus on raising public awareness as a significant step that can contribute towards speed up the decrease in the reliance on private transport and so reduce the traffic air pollution problem in the city.

Table 7.26 The perceptions of the interviewees on the achievement of a decreased reliance on private vehicles.

EGA Respondents	Respondent. 1 (EGA/DM1)	Addressing the causes which have led to an increase in size of the private fleet, such as creating the conditions for importing cars, increasing customs taxes on imported cars and improving the infrastructure of the public transport sector
	Respondent.2 (EGA/DM2)	Provide the infrastructure for public transport, restrict and control imported cars and increase taxes on imported vehicles. This could contribute towards reducing the reliance on private transport in the city.
	Respondent.3 (EGA/TS1)	Actions that must be taken to achieve a reduction in the reliance on private transport include increasing imported vehicle tax, increasing the prices of fuel, and developing an infrastructure for public transportation
	Respondent .4 (EGA/AD 1).	Public awareness can play an important role in reducing the reliance on private transport in the city, as can controlling the importation of vehicles.
GTL Respondents	Respondent. 1 (GTL/DM1).	Reducing the duration allocated for vehicle licences will reduce the size of the fleet of private cars. Also, preventing the importation of old vehicles and raising customs taxes as well as restricting and preventing private cars from accessing the city centre area.
	Respondent .2 (GTL /T01).	Controlling of the technical conditions of vehicles, regular maintenance of private vehicles and increasing the taxes to renew vehicle licences for older vehicles and supporting the public transport sector.
		The action should include a ban on importing polluting old vehicles and raising taxes on

	Respondent .3 (GTL /TA1).	imported vehicles as well as improving the means of public transport will reduce the size of the private vehicle fleet.
ATD Respondents	Respondent. 1 (ATD / DMI)	Developing the public transport sector and improving the services provided for the citizens will be the best way to reduce the reliance of people on private vehicles.
	Respondent.2 (ATD /DRI)	Supporting and developing the infrastructure of public transport must be considered as the main action that should be done. Also, setting strict conditions for imported vehicles.
	Respondent.3 (ATD / DR2)	Developing the public transport infrastructure will improve the services provided for people and that will encourage them to transfer towards using public transport and reducing their reliance on private vehicles for travel.

7.8.2.1. Size of the public transport fleet in the city.

To what extent does public transport contribute to the city's total fleet of vehicles? What are its components?

The respondents from ATD were asked what proportion of the city's total fleet of vehicles consists of public transport. As seen in the Table 7.27 below, public transport in the city includes only taxis and minibuses. This sector is not big enough and lacks the ability to provide good quality services. The size of the contribution of public transport compared to private vehicles is too low, representing less than 5% of the total vehicle fleet in the city. Public transport in Tripoli suffers from many difficulties and obstacles and no support has been provided for this sector.

Table 7.27 The perceptions of the interviewees on the contribution of public transport.

ATD Respondents
Respondent.1 (ATD/DMI) The size contribution of public transport compared to private vehicles is too low. It represents less than 5% of the total vehicle fleet in the city. Public transport includes only taxis and minibuses.
Respondent.2 (ATD /DRI) The public transport in the city includes only taxis and minibuses, This sector is not big enough and cannot provide good quality of services for the people.
Respondent.3 (ATD / DR2) This sector lacks support and represents only a small fraction of the total vehicle fleet in the city. Public transport in Tripoli suffers from many difficulties and obstacles, and no government support has been provided for this sector.

7.8.2.2. Reliance of people on public transport to travel in the city

Do *people rely on public transport to travel in the city?*

The respondents from ATD were asked to what extent people use taxis and minibuses as a means of public transport in the city. As seen in Table 7.28, despite the increase in the size of the private vehicle fleet in the city, many people in Tripoli use public transport for travel and for meeting their needs as well as family visits. People coming from the surrounding areas into the city also rely on public transport while visiting the city for shopping and other purposes. In addition, some of those who have private cars prefer to use taxis when travelling to the city centre and other crowded places, due to the lack of sufficient parking and also because of the problem of car theft in a number of areas.

Table 7.28 The perceptions of the interviewees on the use of public transport in the city.

ATD Respondents
Respondent.1 (ATD/DMI) People use public transport for travel, shopping, visits and moving between work and school. Also, people coming from the surrounding areas depend on public transport while visiting the city for shopping. Students and employees are the main consumers of public transport.
Respondent.2 (ATD /DRI) Many people use public transport for travelling in particular. Students use minibuses to get to school and college because their prices are acceptable and they also cover the areas of higher institutions and universities.
Respondent.3 (ATD/DR2) Some people who have private cars prefer to use public transport and taxis when going to the city centre and other crowded locations where there is a lack of sufficient parking and the risk of car theft in a number of areas.

7.9. Research question seven: the available options for reducing air pollution caused by motor vehicles

What are the available options that should be taken to reduce air pollution caused by motor vehicles in Tripoli city?

Respondents from the EGA were asked what were the main actions that should be taken to reduce air pollution caused by motor vehicles In Tripoli city. As seen in Table 7.29 below, there are many measures that could be employed to reduce the air pollution caused by vehicles in Tripoli and the priority for choosing the alternative options is to resolve the reasons and affecting factors that have led to the occurrence of the problem. The main alternative options suggested by respondents were as follows:

i. Improvements in vehicle engine conditions.

ii. Transferring to producing and using clean fuel in vehicle engines.

iii. Development of environmental legislation.

iv. Improving the status of the EGA and other concerned institutions so that they are in a better position to address the problem.

v. Develop the infrastructure of the public transport sector.

vi. Consideration of public awareness programmes for residents to increase knowledge of air pollution caused by vehicles.

vii. Improvement of the traffic congestion management systems.

viii. Encouraging residents to reduce their reliance on private vehicles.

Table 7.29 The perceptions of the interviewees on the actions required to address the problem.

EGA Respondents
Respondent. 1 (EGA/DM1) The available options could include transferring to use of clean fuel, encouraging the reliance on public transport, the improvement of national environmental legislation, decreasing the reliance on private vehicles, increasing the capacity of EGA as well as creating a monitoring system.
Respondent.2 (EGA/DM2) Control of vehicle technology to ensure engine efficiency, providing support for EGA and other responsible authorities, development of the public transport sector, improving the road network, transferring to unpolluted fuel, and raising public awareness of air pollution issues.
Respondent.3 (EGA/ TS1) Control of imported vehicles, setting catalyst devices on vehicle exhausts, also increasing the capability of EGA, raising public awareness, traffic management, implementation of environmental law, and providing the required support for the concerned authorities, must be considered as alternative options to reduce traffic air pollution problems.
Respondent .4 (EGA/AD1) The main actions include providing financial support for relevant institutions such as EGA, producing and using liquid gas as a fuel for vehicle engines, reducing the reliance on private vehicles for travelling, in addition to controlling the imported vehicles.

7.10. Research question Eight: Management strategy and instruments required to reduce air pollution caused by vehicles in Tripoli.

What are the instruments required (technical, institutional, economic, social, plans and policies etc.) to develop management strategies for traffic air pollution?

7.10.1. Management strategies for reducing air pollution caused by motor vehicles in Tripoli.

Do you think that there is an urgent need for a strategy for managing air pollution caused by motor vehicles in Tripoli? If yes, do you have a proposal or conception of what should be included in this strategy?

The respondents were asked if they thought that there is an urgent need for a strategy for managing air pollution caused by motor vehicles in Tripoli and, if so, what should be included in such a strategy. As shown in Table 7.30, most of the respondents suggested that there is a significant need to create a strategy for reducing the air pollution caused by vehicles. It is necessary to consider and evaluate the current situation of air quality and develop an action plan with specific stages and a time frame for the implementation of the plan. The strategy should involve all of the concerned institutions and sectors and the financial support needed to implement the strategy must be provided.

Table 7.30 The perceptions of the interviewees on the need for a management strategy on air pollution caused by vehicles.

EGA Respondents	Respondent. 1 (EGA/DM 1)	There is no strategy and one is needed to address the problem of air pollution from cars, this strategy should focus on identifying the causes of the problem and developing the procedures and tools to reduce these reasons, the strategy must involve all relevant sectors.
	Respondent.2 (EGA/DM2)	Such a strategy is required and must include several stages and identify the mechanisms for the implementation and human and financial resources and equipment required for the implementation of the strategy.
	Respondent.3 (EGA/ TS1)	The current situation of air pollution in the city requires a strategy, which should be integrated and should include all of the relevant sectors and determine the required instruments, financial support and training of the staff.
	Respondent .4 (EGA/AD 1).	The strategy should be implemented in phases within a time frame as well as provide budgets, technical and administrative staff. The strategy must be integrated and address all issues related to air pollution and the relevant sectors.
	Respondent. 1 (GTL/DM1).	A strategy is needed and should include all relevant sectors, such as the Department of Traffic Police. It must solve the problem of

		traffic congestion and control for imported vehicles as well as develop the national law.
GTL Respondents	Respondent .2 (GTL /T01).	There is an urgent need to create a strategy to resolve the problem. The strategy needs technical staff, a budget and a focus on resolving the increase in the private vehicle fleet by controlling imported vehicles and providing support for GTL in terms of managing traffic congestion.
	Respondent .3 (GTL/TA1).	The problem of traffic air pollution can be resolved through establishing a programme or action plan. This plan may be developed in future to become a strategy, as creating a strategy needs extra money and time

7.10.2. The instruments required for developing a strategy

What are the instruments required (technical, institutional, economic, social, plans and policies, etc.) to develop management strategies for air pollution resulting from vehicles?

The respondents were asked what instruments (technical, institutional, economic, social, plans and policies, etc.) are required to develop management strategies for air pollution caused by vehicles. As seen in Table 7.31 below, most of the EGA respondents mentioned that the preparation and implementation of the strategy for the management of air pollution from cars requires the provision of many tools, including legal, institutional and financial ones. The legal issue involves developing the current environmental laws. It is also necessary to provide financial support for all stages of the strategy and also the training and qualification of technical staff to enable them to participate in the development and implementation of the strategy, as well as providing laboratories and equipment to measure and monitor the air quality in the city. Most of the GTL respondents stated that the strategy needs the government to provide support for concerned sectors such as GTL, who must be involved in the strategy. The required instruments include financial support and there should also be a focus on training programmes for GTL staff in terms of traffic management, in addition to education for traffic police on the problem of air pollution from cars.

Table 7.31 The perceptions of interviewees on the required Instruments for developing a strategy

EGA Respondents	Respondent. 1 (EGA/DM 1)	The instruments include a national plan for air quality control, the development of laws and legislation and the provision of training and qualifications for technical staff. Also, the availability of financial support necessary to establish and implement such a strategy.
	Respondent.2 (EGA/DM2)	The instruments include the legislative framework of the strategy, and developing the institutional facilities. The third instrument is the provision of financial support to establish and implement the proposed strategy to ensure the implementation of all stages and within the specified times.
	Respondent.3 (EGA/ TS1)	The instrument includes the development of environmental law and human resources by providing training and rehabilitation, financial support as well as considering social issues.
	Respondent .4 (EGA/AD 1).	The strategy needs many instruments such as financial and human resources to conduct an environmental survey for evaluating the status of air quality. Providing equipment and devices to control and monitor air quality is required, too.
GTL Respondents	Respondent. 1 (GTL/DM1).	Respondent. 1 (GTL/DM1). The instruments include financial support for all relevant sectors, including transportation, traffic police, the provision of new equipment and technologies for the purpose of traffic congestion management
	Respondent .2 (GTL /T01).	The strategy needs a lot of instruments, such as financial support for all concerned sectors such as GTL, who should be a part of the strategy. The instruments also include the control of imported vehicles and training for the traffic police.
	Respondent .3 (GTL /TA1).	The instruments include providing education for GTL staff, and technology and equipment for traffic police to manage traffic congestion. The strategy should solve all of the difficulties, resolve all of the obstacles, and involve the traffic police as a part of the strategy.

7.11. Chapter Summary

This chapter has presented an analysis of in-depth interviews with ten experts and responsible people from the three concerned institutions in the study area to obtain the information and data needed to address the research questions.

In analysing the interviews, codes were selected to represent the respondents and their authorities and positions, the questions were developed in a sequential form and all of the respondents' answers to the questions have been presented in the form of tables. The chapter also demonstrated the different answers to the partial and main questions.

A summary of the responses obtained from each institution's respondents to each question has also been presented.

Chapter Eight

Discussion of the Findings

8.1 Introduction

This study has presented in the previous chapters a large volume of data gathered from various primary and secondary sources which indicates that the city of Tripoli suffers from the problem of air pollution caused by vehicles, and that there are many factors which have had a significant effect on this problem and have increased it. Some of these factors relate to the legal aspects, including the weakness of the existing environmental legislation, and to other aspects regarding the weakness of the concerned institutions, particularly the General Environmental Authority, which suffers from many difficulties and obstacles that have prevented it from addressing the problem of air pollution from cars. These factors also include the poverty of the infrastructure in the public transport sector and the lack of environmental awareness among the public regarding the risks resulting from a continuing dependence on the use of private transport in the city. Another problem is the failure to rationalize fuel consumption: the data indicate that large quantities of fuel are being consumed in vehicle engines and the types of fuel being consumed include petrol and diesel, both of which cause pollution.

The data and information gathered show that there have been some attempts by the government to address the problem, but that the actions taken were ineffective because of their limitations and because there was no action plan or strategy in place to address the problem. In addition, the actions were taken without coordinating the different concerned sectors, which made the actions ineffective in addressing the problem or mitigating the damage.

This chapter reviews all of the measures related to the topic of air pollution from cars in the study area, through discussing the evidence gathered from various sources of data, including questionnaires, interviews, direct observations and previous studies.

The cross-referenced table below summarises the evidence from different sources; the purpose in arranging the data in the table was to facilitate the extraction of evidence by the reader. The table contains four sources of evidence: questionnaires, interviews, direct observation from fieldwork, and evidence from the literature review.

The interpretations and discussions in this chapter include the main issues related to the topic of air pollution caused by vehicles, which have already been categorized in previous chapters. The results obtained from the analysis of the issues according to these categories lead to an understanding of all of the issues related to the topic of air pollution caused by motor vehicles in the study area.

In what follows, the findings from the questionnaire, interview and fieldwork observation are compared with the corresponding evidence obtained from the literature review, to investigate the problem of air pollution caused by vehicles and the factors which have led to this problem, to review the available options for addressing it, and to offer suggestions about improving the status of air pollution caused by vehicles.

Management strategy on air pollution caused by motor vehicles in Tripoli	One hundred and twenty-eight respondents commented that there is a need for a management strategy on air pollution caused by vehicles in Tripoli**(Section 6.10 / Table 6.40).**	The majority of respondents believed that a strategy is important for protecting air quality and must consider the current status of air quality **(Section7.10.1 / Table 7.30).**	EGA and other concerned authorities in the city lack a strategy for addressing the problem owing to the shortage of human resources and facilities required to establish a strategy on air pollution caused by vehicles.	The most important keys to the development of a strategy for reducing the number of motor vehicles should include the identification of the most important environmental problems and estimates of the potential damage to public health and the environment (Komjim and Love, 2001).
	One hundred and thirty-five respondents suggested that there is a need for certain instruments to be provided to create and implement a strategy on air pollution caused by vehicles **(Section 6.10 / Table 6.41).**	Most EGA respondents recommended that the required instruments should include legal, institutional and financial tools **(Section 7.10.2 / Table 7.31).**	Most institutions need extra support to be involved in the strategy, to give people the financial and legal qualifications they require and to provide the required instruments.	The air quality and management strategies require a clear action plan in stages, for the short, medium and long term, which must determine the time frame which should make it clear what will be managed and implemented at every stage (Jon, 2007).

8.2. Findings related to air quality in the study area

8.2.1 Air quality status in Tripoli city

The air pollutants which may be emitted from different sources can cause changes to occur in the physical compounds of the atmospheric air, and could damage humans, animals, plants and property. Damage to air quality and the environment can occur if the concentrations of air pollutants exceed the standards and criteria of air quality, which differ from country to country.

The majority of respondents to the questionnaire suggested that the air quality in Tripoli has been subjected to harmful substances produced from different sources of air pollution; the respondents believe that the air quality in the city centre has been reduced more steeply than that in other areas of the city, and that the damage is more severe in the summer. The evidence from the interviews shows that the respondents from EGA suggested that the air quality in the city had been damaged, but that an assessment of the air quality was impossible, owing to shortage of required data on the amount of air pollution emitted from different sources.

The background from the direct observations gathered during the field visit indicates that there are no air quality monitoring systems in the city and also that the EGA does not have the equipment to take and analyses samples of air pollution caused by vehicles. Reports from the EGA confirm that there is a need for such monitoring systems, equipment and instruments. The technical reports published by the EGA show that there is an absence of continuous measurements of air pollutants with a lack of specified classification of air quality in the city for the reasons mentioned above. The data gathered from the emissions inventory for the period 2005-2010 showed that vehicle emissions in the study increased during the period 2005-2010. Specifically, CO emissions increased by an annual rate of 10.05% and NMVOC increased by 10.09%, NOx increased by 10.03% and the rates of annual increase of NO_2, $PM_{2.5}$, PM_{10}, $PM_{exhaust}$, CO_2 and SO_2 were 9.89%, 9.83%, 9.87%, 9.38%, 9.47% and 15.48%, respectively. These great quantities of vehicular emissions could cause an imbalance in the physical components of atmospheric air and could lead to pollution and damage to the air quality in the city. During informal discussions during the fieldwork visit, most people confirmed their concerns about the poor air quality in Tripoli, particularly in the summer season when the temperature rises and the air is in a stable state. They reported a sense of suffocation and difficulty breathing in some cases because of the poor air quality, which they considered to be caused by motor vehicles.

The situation reported and observed in Tripoli is consistent with evidence gathered from the literature review, indicating that the lack of air quality data for several developing countries and the increase in other data gaps, such as the lack of availability of comprehensive emission inventories, limits the efforts of governments to resolve the problem of urban air pollution (Gurjara et al., 2008). Some guidelines, regulations and emissions standards have been issued to identify air quality levels. These criteria offered by the international organizations, as well as other criteria issued by other countries, were created in order to protect air quality around the world (Baldasano et al. 2003).

Therefore, the synthesis of all the evidence discussed above indicates that the EGA, which is the higher national authority responsible for air quality, lacks data and information as well as periodic and continuous traffic air pollutants measurements. In addition, the EGA does not have fixed monitoring stations to monitor air quality, which contributes to the inability to evaluate the actual situation of air quality in the city. The evidence gathered failed to produce reliable figures and data on the status of air quality in the city because of the lack of necessary data and information. However, inferences were made about the conditions which can damage air quality, including the increasing number of vehicles, the severity of traffic congestion and the large quantity of fuel consumed fuel by vehicle engines. In addition, some evidence was based on direct observation, through informal feelings about the quality of the air they breathe, particularly during the summer. At the same time, the evidence obtained from direct observations provided figures and data about the quantity of pollutants emitted by cars for the period 2005-2010, which gave an indication of the presence of air pollutants emitted into the atmospheric air in the city, which could lead to pollution and damage the air quality in the city. However, it is in fact impossible to evaluate accurately the level of damage to the air quality without data about the air pollutants emitted from other sources. Such data were unavailable, In the absence of an air quality monitoring system, it is impossible to be sure that the air pollution does not exceed the limits that lead to an imbalance in the level of air quality in the city.

Finally, it is noticed that attention to the issue of air quality monitoring in the study area has not improved over previous years, as the authorities remain unable to provide the necessary monitoring stations to monitor air quality and the institutions have a weak capacity to follow up the subject of air quality.

Given the lack of financial and technical support necessary to carry out this task, the air quality in the city can generally be susceptible to degradation as a result of the increase in the number of cars and in the amount of fuel consumed by vehicles. Consequently, more action needs to be taken by the concerned authorities, especially the Environment General Authority, to bring the monitoring of air quality up to the required standard.

8.2.2. Main sources of air pollution in Tripoli

Air pollution may occur due to natural sources and human activities. Human activities include industrial activities, power generation, agriculture, land transport (private vehicles), commercial land transport and waste disposal (Bernard et al. 2001).The evidence from the questionnaire indicates that the major source of air pollution in Tripoli is motor vehicles, while the second source is domestic waste disposal, and the third source is industrial activities. In interviews, consistent with the questionnaire evidence, the majority of respondents suggested that the major source of air pollution in Tripoli is land transport, due to the increase in the size of the vehicle fleet in the city, which has led to an increase in the quantities of fuel consumed and has produced harmful pollutants which contribute to the air pollution problem in Tripoli. The respondents explained that the disposal of domestic waste without treatment is the second source of air pollution in the city, while the light industries established in the city, including the smelting of heavy metals, could be considered as the third highest source of air pollution in Tripoli.

Evidence from direct observations during the field visit to the study area revealed large-scale industrial activities including power plants outside the city and small-scale activities carried out at a number of sites, including metal smelting and food processing plants, which can be important sources of air pollution in the city. The large numbers of cars and the severity of traffic congestion on the road network are confirmed by data obtained from the Department of Vehicle Registration, which shows that the number of vehicles in the study area in 2005 was 635303 vehicles, giving a ratio of610 vehicles/1000 persons. This increased to 1021304 vehicles in 2010, representing 879 vehicles/1000 persons. The data also confirmed that the size of the private vehicle fleet is too high; representing 77.70% of the total vehicle fleet, while public transport vehicles represented only 4.85% of the total vehicle fleet. These include only taxis and minibuses, and there are no large buses, trams or trains.The evidence from the literature review confirms that air pollutants are an increasing environmental problem in the cities, due to sources including the increased urban population, lack of control over industrial activities, and the extraordinary emission of pollutants from motor vehicles (Bickersta and Walker, 1999). A comparison with the other sources of air pollution in big cities shows that land transport contributes 70% of the total emissions of CO, 50% of HC, 30-40% of NOx, 30% of SPM and 10% of SO_2 (Goyal et al.2006).

From the above, it is clear that the evidence gathered from different sources is largely consistent on the source of air pollution in Tripoli, pointing to motor vehicles as the highest source of air pollution in the city. This is due to the increase in vehicle numbers and the quantity of fuel consumed, which is composed only of petroleum products including diesel and petrol, both pollutant fuels, which can emit harmful substances into the atmosphere. The evidence from various sources agreed that the second source of air pollution in the study area is the disposal of domestic waste, as both householders and companies dispose of waste in the public areas, fields and spaces, without treatment, which can emit large amounts of air pollutants in the city. This was clear during the field visit to the study area and that needs resolving in order to protect the air quality in the city. The majority of respondents also believe of that light industrial activities are a source of air pollution in the city as many light industries have been established and have contributed to the air pollution problem. The presence of many light industries was observed in the study area during the field visit.

To summarize, the majority of sources agreed on the major sources of air pollution in Tripoli, suggesting that motor vehicles are the main source of air pollution followed by the disposal of domestic waste and light industrial activities. It is impossible to determine the contribution of these sources on air pollution in the city, due to the lack of accurate data and information about the pollution emitted from these sources. However, this study has provided an inventory of vehicular emissions calculated by applying COPERT software as presented in Chapter Five of this study.

8.3. Findings related to the contribution of motor vehicles to air pollution in Tripoli

The contribution of land transport to air pollution in cities is large; in some cases, it can represent 70-80% of the total air pollution, although the amount varies from one city to another according to several factors, including the economic situation and legislation, as well as the type of fuel, vehicle fleet conditions and other factors.

The majority of respondents to the questionnaire suggested that the emissions resulting from land transport make the biggest contribution to air pollution in the city; they thought that the kind of fuel consumed in vehicle engines in Tripoli is polluted and has damaged the air quality: the consumption of this fuel can emit thousands of tonnes of air pollutants each year, which significantly contributes to the air pollution problem.

Similarly, the interviewees largely agreed that the emissions resulting from land transport are major contributors to air pollution. They stated that the fuel consumed by vehicle engines in Tripoli, including petrol and diesel, produce pollutants that have the ability to damage the air quality. The respondents also indicated that the increased number of vehicles in Tripoli has led to the consumption of large quantities of fuel in vehicles engines and the consequent emission of thousands of tons of air pollutants each year. This indicator supports the view that land transport in the study area is a significant contributor to high rates of emissions and, hence, to the air pollution problem in the city.

The evidence derived from the direct observations gathered during the field visit to the study area has provided more details about the contribution of vehicles to air pollution in the study area. Three cases of emissions of white dense smoke emitted from three different vehicles were observed. Two cases were on the highway and the third case was in the city centre. Data gathered from direct measurements taken during the field visit indicated that pollutants emitted from vehicles in the study area are highly concentrated during certain periods of the day, particularly at the peak of traffic congestion. In addition, the inventory of vehicular emissions made in this study for the period 2005-2010 (presented in

Chapter Five) showed that there was a dramatic increase in the amount of vehicular emissions in the study area. As a result of the increase in the size of the vehicle fleet, vehicular emissions of CO, VOC, NMVOC, NOx, NO, NO_2, $PM_{2.5}$, PM_{10}, $PM_{exhaust}$, C02 and SO_2 per capita per year have increased from 24.46, 2.22, 1.99, 5.89, 5.62, 0.26, 0.22, 0.32, 0.087, 2007.91 and 0.156 kilograms in 2005 to 35.33, 3.21, 2.87, 8.47, 8.10, 0.38, 0.31, 0.46, 0.117, 2826.84 and 0.387 kilograms respectively in 2010.

Most of the evidence mentioned above is consistent with the claims made in the literature. For example, Mayer (1999) has stated that the means of land transport are the largest source of air pollution in cities, as they emit pollutants that are harmful to both health and the environment. Soumak et al. (2012) suggested that the combustion of petrol and diesel fuels in vehicle engines produces air pollutants including nitrogen oxide, hydrocarbons, and carbon monoxide, in addition to large amounts of particulates, mostly lead. Brock et al. (2007) thought that the means of land transport have contributed most to atmospheric pollution, as these means emit harmful pollutants as a result of fuel combustion in vehicle engines.

The accumulation of all of the evidence mentioned above supports the view that Tripoli is subjected to air pollution caused by vehicles, and that the contribution of vehicles to the air pollution problem in the study area is increasing, in the absence of any system for controlling the number of vehicles and the type and amount of fuel consumed. However, the evaluation of the contribution of vehicles to air pollution in the city still requires more investigation.

The contribution of vehicles to the air pollution problem in the study area will rise as long as the number of private vehicles continues to increase and pollutant fuel continues to be used in large quantities, especially given the inadequacy of public transport infrastructure. Considerable attention and actions are needed to address this problem, but these have not been available during the past few years in the study area, as confirmed by the evidence already discussed in the previous section. The weakness of the public transport sector, lack of control on imported vehicles, and deficiencies in the concerned institutions, such as the EGA's administrative difficulties, have all helped to increase the problem in previous years.

To summaries this section, the evidence points to the significant contribution of cars to the problem of air pollution in Tripoli, but suggests that there is difficulty in determining the size of the contribution of vehicles to air pollution in the city, due to the lack of data and information. This is attributable to the lack of human and technical resources. Therefore, there is a need to conduct surveys of all sources of air pollution in the city, in addition to continuing to measure pollutants caused by cars in order to determine the extent of the contribution of cars to the city's air pollution. This requires the provision of the technical and financial resources necessary to carry out such studies and surveys.

8.4. Findings related to the air pollution caused by motor vehicles in Tripoli

8.4.1. Air pollution caused by motor vehicles in Tripoli

The information from the questionnaire shows that the majority of respondents believe that motor vehicles emit harmful substances that affect the air quality, causing the problem of air pollution by cars in the city. The majority of the interviewees also suggested that Tripoli has suffered from air pollution caused by vehicles because of the high numbers of vehicles and the great quantities of fuel consumed in vehicle engines.

The evidence obtained from the interviews is consistent with what was reported on the questionnaire, as most of the EGA respondents thought that Tripoli has suffered from traffic air pollution due to the increased numbers of vehicles and consumption of great quantities of fuel by vehicle engines. The respondents stated that it was impossible to check the extent to which vehicles have contributed to the air pollution problem in the city as a result of the lack of required information and data concerning the amount of emissions caused by vehicles compared with the total air emissions in the city, which are also not measured.

Direct observations yielded evidence of traffic congestion on the road network on most main roads and at filling stations. Moreover, the data and information obtained from the DVR showed that the number of motor vehicles in the city has increased, from 635303 vehicles in 2005, representing 610 vehicles/1000 persons, to 1021304 vehicles in 2010. In addition, the data gathered from the emission inventory for 2005-2010 indicated that the quantity of air pollutants emitted by motor vehicles in the study area has gradually increased by an average annual rate of 11.09%. The vehicular emissions of CO, VOC, NMVOC, NO_x, NO, NO_2, $PM_{2.5}$, PM_{10}, $PM_{exhaust}$, CO_2 and SO_2 increased from 25,466.55, 2,314.35, 2,071.61, 6,128.81, 5,853.83, 274.98, 228.15, 335.51, 90.88, 2,090,530.00 and 162.62 tons in 2005 to 42,051.96, 3,728.66, 3,337.78, 9,846.55, 9,407.23, 439.32, 363.17, 535.84, 142.35, 3,284,687.43 and 449.85 tons in 2010. This represents average annual rates of 10.09%, 10.07%, 10.07%, 10.01%, 10.02%, 9.90%, 10.23%, 9.86%, 9.52%, 9.47% and 22.77%, respectively.

These findings are consistent with reports in the literature; for example, Cervero and Kockelman (1997) stated that emissions from vehicles are the main cause of air pollution in the urban areas, as there are a lot of pollutants which are attributable to the use of private transport.

The evidence presented above shows that the vehicle fleet in Tripoli has increased in previous years and is continuing to increase, and all the evidence suggests that, as a result, motor vehicles are considered to be the biggest source of air pollution in the city. The views of the respondents in this respect are supported by the total vehicular emissions for the period 2005-2010.

All sources of evidence represented above show that the vehicle fleet in Tripoli has increased in previous years and is still continuously increasing. The inventory of vehicular emissions showed an annual increase in air pollutants emitted from vehicles in Tripoli. Thus, based on all this evidence, motor vehicles in Tripoli are considered the main source of air pollution in the city. It is clear from the evidence that the lack of research studies and surveys about the air pollution caused by motor vehicles in Tripoli and at the national level has led to an inability to manage and resolve the problem.

8.4.2. Factors affecting air pollution caused by motor vehicles in Tripoli

It is generally agreed that the atmospheric air suffers from pollution as a result of fuel combustion in vehicle engines. However, where the kind and concentration of air pollutions depend on a variety of affecting factors, these can play a significant role in the occurrence and scale of the problem. The respondents involved in the study were asked about the main affecting factors that have contributed to the occurrence and rise of the traffic air pollution problem in Tripoli.

The majority of respondents to the questionnaire suggested that the factors that have contributed to the occurrence of an increase in the air pollution problem caused by motor vehicles in the study area are the increased size of the vehicle fleet and the failure to implement environmental laws. These and other significant factors were ranked in the following order:

i. Increase in the vehicle fleet size

ii. Non-implementation of environmental laws

iii. Lack of public transport

iv. Lack of public awareness on environmental matters.

v. Vehicle engine operation status.

The evidence from the interviews shows that the majority of respondents believed that the factors that had the greatest effect were the increase in the vehicle fleet, the types and quantities of fuel consumed, economic development, population growth, the lack of public transport, the weakness of the environmental legislation on the control of air quality, the lack of public awareness of traffic air pollution, and an increase in the severity of traffic congestion.

The evidence gathered from the direct observation of the factors affecting air pollution caused by vehicles, data and information collected through field visits and looking at the reports and documents available to the concerned authorities indicate that the most important factors that led to the emergence of the problem of air pollution from cars include the increased economic growth rate of the country, which contributed to an increase in private vehicles ownership. This is increasing at a rate of about 100,000cars annually. Moreover, fuel consumption data confirm that the spent fuel is contaminated fuel, resulting in large amounts of air pollutants. The problem is exacerbated since fuel is consumed in large quantities in the city because of its low price. The observed phenomenon of traffic jams on the road network also increases the amount of pollutants from cars, as do the weak domestic laws and regulations, underdeveloped transport sector, which consists only of taxis, and does not represent more than 5% of the total cars, and the lack of environmental awareness among the citizens regarding the issue of air pollution. These factors contribute to the increased reliance on cars and lack of fuel efficiency.

The majority of the evidence gathered through questionnaires, interviews and direct observation, mentioned above, is compatible with what was stated in the literature. For example, Atash (2007) stated that the huge increase in the population size and increased economic activities, as well as the growing numbers of vehicles on the road networks in cities, have contributed to the increased air pollution rates in the major cities of developing countries, and Baldasano et al. (2003) state that one of the most powerful factors leading to the existence of air pollution in the cities is the increase in population size. Marshall et al. (2005) suggested that the density of the population might increase or decrease in pollutants emitted by transportation where that depends on the flexibility of pollutants density. Bindra and Hokoma (2004) believe that the extreme increase in the number of motor vehicles is a factor that affects air pollution caused by vehicles, while, Cervero (1988) argues that the factors include an increase in the numbers of private cars, which is consistent with what was stated by Atash (2007).

The type of fuel used also plays an important role in determining the types of pollutants emitted by vehicles. The lead compounds and sulphur contained in fuel can result in lead and sulphur emissions; both pollutants cause damage to health and the environment (Komjim and Love, 2001; Latham et al. 2001). Also, Kenworthy and Laube (2002) and Cervero (2000) state that the health risks generated by vehicles that consume fossil fuels are significant. Gorham (2002) stated that public transport management is one of the most important issues in improving air quality and reducing the pollution caused by vehicles.

According to Mustafa and Najib (2008), the environmental legislation in Arab countries is generally weak, and most of these environmental laws and standards of pollutant concentrations were set according to standards and criteria already applied in developed countries. Faiz (1990) mentioned that the damage to health, the environment and the economy caused by vehicles is exacerbated by non-compliance with the laws and lack of implementation of environmental legislation governing the concentrations of pollutants. Concerning public awareness as a factor, Bickersta and Walker (2001) stated that there is still a need to develop public awareness about the problems of air pollution from cars by providing publications, brochures and other media to raise awareness. Sarath et al. (2003) stated that the phenomenon of traffic congestion on the road network is one of the main reasons responsible for increasing the amount of emissions from cars; this was supported by Irving and

Morcrieff (2004), who stated that the pollutants emitted by vehicles depend on various factors including traffic congestion on the road network. Park (2005) mentioned that there are three main factors: the characteristics of the vehicle, the operating conditions and the weather conditions. Binndra and Hokoma (2004) stated that the length of the daily temperature inversion created a high concentration of emissions in the area surrounding sources of contamination, owing to the limited dispersion of pollutants. Gorham (2002) stated that heat, sunlight and humidity can influence the amount and type of atmospheric reactions that occur, as well as the amount of evaporation (VOC) emissions from vehicles (hot soak) and refuelling systems.

It is understood from the evidence mentioned above that the contribution of affecting factors to the air pollution resulting from vehicles was as follows:

i. Economic growth in Libya over the past years has had an impact on various aspects of life, including the ability of most citizens to have their own vehicle, especially given the availability of bank loans for the purchase of private cars; this has led to an increase in the size of the vehicle fleet in the city, which has increased the amount of pollutants emitted from cars, while economic growth has not been used to address the problem, as no financial support has been provided to address the problem of air pollution caused by vehicles.

ii. Population growth has led to increased urbanization and has also increased the demand for road transport, particularly private vehicles; this has helped to increase the amount of vehicular emissions and has thus contributed to the increased air pollution caused by motor vehicles.

iii. The vehicle fleet in Tripoli has increased greatly, by approximately one hundred thousand vehicles yearly, which has made a significant contribution to the increase in vehicle emissions in the city, as confirmed by the results of the emissions inventory for the period 2005-2010.

iv. Petrol and diesel fuel, which are considered as polluting, are being consumed in greater quantities; this has led to an increase in the quantity of air pollution caused by vehicles.

v. The public transport fleet is very limited and weak, representing less than 5% of the total vehicle fleet, which has led to an increase in the use of private vehicles and increased air pollution caused by vehicles.

vi. There is no air quality law in the country, and the Environmental Protection Act 15/2003 is insufficient in terms of provisions related to air quality and air pollution caused by vehicles; the environmental law does not give enough consideration to air quality issues, and the law has not been fully implemented, for many administrative, technical and social reasons.

vii. There is low public awareness of the issues relating to air pollution from cars in Tripoli, because there are no organized programmes available to promote public awareness of air quality issues.

viii. The city of Tripoli is suffering from the problem of traffic congestion on the road network. The reasons for the severity of this traffic congestion are the significant increase in the number of different kinds of vehicles during the past years, the condition of the road network, since some roads do not meet the required standard, inadequate parking provision in terms of both numbers and quality, and the lack of required instruments for managing the traffic on the road.

ix. The climate of the city is characterized by a stable atmosphere in most seasons of the year, and by high temperatures, averaging 47° centigrade in summer and high relative humidity.

Consequently, these factors need to be considered in any action plan or strategy which the government may propose in order to address the air pollution caused by vehicles in Tripoli.

8.5. Findings related to the effects of air pollution caused by motor vehicles in Tripoli

Motor vehicles have serious effects, including health effects, such as cancer, respiratory system illness, genetic mutation and blood toxicity; environmental effects, such as climate change and damage to ecosystems and the landscape; and economic effects, on the infrastructure, tourism and crop production (Briggs et al. 1997).

8.5.1. Health effects of traffic air pollution

The evidence from the questionnaire shows that the majority of respondents were of the opinion that the pollutants emitted by vehicles have effects on public health. Most of the EGA interviewees referred to indications of the existence of health effects resulting from exposure to traffic air pollution caused by an increase in the number of vehicles and also an increase in the amount of fuel consumed by vehicle engines. The interviewees saw a need for surveys to determine the types and extent of such damage, as no data are currently available. However, in the direct observations, some taxi drivers who had been working for a long time have reported that they were suffering from respiratory disease as a result of their exposure to pollutants emitted by cars. Some traffic police also complained of respiratory disease. The evidence from previous studies agrees with the statements made by the respondents; for example, McKeown (2007) stated that traffic air pollution is related to increased rates of respiratory disease, and also to morbidity (illness) and mortality (early death), with the severity and risks of these pollutants changing according to the age and medical conditions of each individual. In addition, Rimmington (2006) stated that children are especially vulnerable to the effects of air pollution, because their lungs, metabolism and immune systems are still developing, and so they have higher rates of respiratory infection as well as activity patterns which lead to higher exposure.

It is understood from the evidence mentioned above that the air pollution resulting from vehicles in Tripoli has produced some health problems, but there is no information about the extent or types of these diseases because of the lack of health surveys. The EGA interviewees confirmed the lack of such surveys, due to the lack of trained personnel specializing in determining the types of diseases resulting from exposure to air pollution caused by cars in the city. Despite the lack of data, the evidence which has been reviewed indicates that health effects caused by exposure to air pollution by cars are possible.

8.5.2. The environmental effects

The majority of the respondents to the questionnaire believed that the air pollution from vehicles in Tripoli has produced environmental effects, including effects on plants, water resources, vegetation and climate conditions as well as on materials and buildings. The EGA respondents confirmed their inability to evaluate such environmental effects in the study area, due to the lack of field surveys and intensive researches and studies in the study area.

Direct observations, however, provided evidence of the effect of pollution on building walls in the city centre, as well as on trees, which tend to become yellow because of the accumulation of pollutants on the leaves. The reports showed that the EGA has failed to conduct any studies of the environmental impact of air pollution caused by cars in the study area because of the lack of specialized expertise and the lack of equipment needed to conduct such surveys.

The evidence from the literature review confirms that exposure to air pollutants has an impact on the environment. For example, Komjim and Love (2001) mentioned the effect on environmental resources, including soil, water and air resources. In addition, Ozden (2008) mentioned the damage to ecosystems, including damage to plants and the reduced productivity of agricultural crops, damage to property, and the impact on visibility.

It is clear from the evidence discussed above that it is likely that exposure to pollutants emitted from motor vehicles in the study area will have environmental effects, as indications of this can be observed on some buildings and plants in the study area. However, it was agreed that it was impossible to identify every kind of environmental effect resulting from air pollution caused by vehicles, because no research has been conducted on the evaluation of such effects, owing to a lack of interest by the government and relevant institutions. The EGA as the authority responsible for such studies was unable to carry them out, due to the lack of specialized staff and the absence of the required equipment and instruments, as well as a lack of financial support.

8.5.3. The economic effects

The respondents to the questionnaire claimed that there are economic impacts resulting from air pollution caused by vehicles in the study area, due to the need to provide funding for the treatment of diseases and to re-build the damaged environmental resources. Similarly, the EGA interviewees pointed out that the economic effects of air pollution caused by vehicles in the study area include the funds required to repair all of the damage that has occurred as a result of exposure to air pollution by vehicles as well as the funds needed to treat diseases and return environmental resources to their original state, which would be costly. They confirmed that no evaluation of economic effects had been carried out, and that information needs to be collected on the damage to health, the environment and society to enable such effects to be assessed.

The evidence gathered from the direct observations indicates that there are economic effects, based on the large quantities of vehicular emissions generated during the period 2005-2010.There are also economic effects on individuals and on the government, including the cost of treating diseases which may be caused by exposure to air pollution from cars, and at the government level it is very expensive to address the environmental impacts, as considerable funding is needed to return the situation to its natural state.

The prior discussion in the literature points to the economic effects of pollution, including the effect on the style and standard of living and on the tourism sector.

Air pollution promotes a greater reliance on the use of air conditioners in vehicles and homes, and this leads to increased energy consumption and needs money (Sirikijpanichku et al. 2006), while Mustafa and Najib (2008) mentioned that Arab countries lose more than five billion dollars annually as a result of the effects of air pollution on health and the environment. Faiz et al. (1996) suggested that the costs include damage to buildings and historical monuments, as well as reduced crop yield and a loss of views of the landscape.

It is clear from evidence from different sources that economic effects can be expected as a result of exposure to air pollution emitted by cars in the city. Health, the environment and materials have been damaged and require repair and maintenance. Consequently, considerable funding is needed to treat diseases and maintain affected properties, such as historic buildings, as well as re-habituate the affected ecosystem. The respondents insisted on the need to evaluate all of the damage caused by air pollution emitted by vehicles and then to assess the value of the damage so that the actual value of the economic effects of air pollution from cars can be assessed. Such estimations have so far been unavailable because of the lack of human and technical capabilities as well as the instruments needed to conduct such assessments.

To sum up this section, it is noted that most of the evidence from the questionnaire, interviews, direct observations, as well previous studies point to health, environmental and economic effects in Tripoli resulting from air pollution caused by vehicles. However, the EGA, as the responsible authority in Libya, had great difficulty in determining the cost of the various types of damage, duet the lack of comprehensive data and information about the size and concentrations of pollutants and also the lack of surveys of the potential damage caused by exposure to air pollution resulting from cars. This was because such surveys and environmental studies need experts on various topics, including the environment, economics and health, who were unavailable. The evaluation of the health, environmental and economic impacts of air pollution from cars needs a large volume of data and information and also technical expertise.

8.6. Findings regarding the actions taken to reduce air pollution caused by motor vehicles in Tripoli

Many countries seek to address environmental problems and employ their available capabilities. In order to achieve that, the economic circumstances play a significant role in determining the scale and types of measures taken by the government to address environmental problems, such as traffic-generated air pollution. The measures taken by different governments differ; some countries have moved towards developing laws and legislation to monitor air quality and issuing legal mechanisms for following-up and implementing these laws, while others have the potential specialized resources to develop programmers and conduct studies to determine the size of the problem and propose successful solutions to the traffic air pollution problem. Other countries, however, have paid less attention to such problems because it is not apriority for them, and most of these countries do not have the financial means to address the problem.

8.6.1. The roles of the local institutions

The activities and capabilities of the concerned Institutions and authorities in terms of protecting the air quality from air pollution caused by vehicles are considered as one of the most significant factors that can contribute towards solving the problem. However, implementing the necessary measures to address this problem depends on the potential and capacity of these institutions. Therefore, the quality of the institutions and their functions as well as their being given the legal and administrative force to carry out their tasks, are prerequisites for the success of these institutions in addressing the problem and reducing the risks.

8.6.1.1. The role of the Environment General Authority

The majority of respondents to the questionnaire believed that the EGA has no action plan for protecting air quality from vehicle emissions, does not provide reports on this problem, and has no public awareness programmes for citizens about the problem or related issues. In addition, the EGA fails to measure the pollutants emitted by cars; no data are available about the levels of vehicular emissions.

The evidence from the interviews shows that EGA was established in 1999 as a higher authority responsible for protecting and managing environmental issues. The interviewees from EGA stated that the roles of EGA concerning air quality issues as well as air pollution caused by vehicles include measuring air pollutants, and proposing relevant programmes and plans in order to manage air quality. The respondents confirmed, however, that EGA faces several difficulties and obstacles in performing most of these tasks. In terms of the facilities available at EGA for controlling air quality, the EGA interviewees indicated that the government had not provided EGA with enough financial support in previous years, as it lacked the equipment and instruments needed to measure and analyse the air pollutants caused by vehicles or other sources. The EGA interviewees confirmed the absence of an air quality monitoring system; also, the technical staff were not qualified in the field of air pollution studies, as there were no regular training programmes on such skills. Consequently, there was no measurement of air pollutants, including the pollutants emitted by cars.

Direct observations revealed that the EGA has taken some actions as the higher authority responsible for protecting the environment in the country, that is authorized to take all of the required actions. The environmental law authorizes the authority to implement all of the needed actions and procedures in term of protecting air quality, and for the purpose of implementing its tasks, the EGA created a department called “Management Control and Protection of the Environment”. This department has a section called the “Department of Environmental Monitoring”, and another section called " Combat of Air Pollutants”. These two sections have technical staff, with five engineering graduate from Libyan universities. However, this department does not have expertise in air quality research, as they do not receive a lot of training on the measurement and analysis of air pollution caused by vehicles. In addition, this department had not conducted a comprehensive survey of the sources of air pollution including the air pollution caused by vehicles. The EGA has another department named the “Department of Technical Affairs and Laboratories”, whose tasks include analyzing pollutants, including the air pollutants emitted by vehicles and also collecting samples from polluted sites. This department conducts its functions through several sections, including “Air Pollutants” which consists of three technicians. However the department lacks the equipment needed to collect and analyze air samples, and suffers from a shortage of intensive training for technical staff. The EGA report showed that, in April 2010, the department imported a number of devices and equipment for measuring air pollutants, including a mobile laboratory for measuring air pollutants, but using these devices requires extensive training.

The evidence from previous studies indicates the importance of the role of the concerned authorities, and the need for the institutions to have the capability to carry out their tasks. This can be inferred from Faiz (1990), who stated that the local authorities should promote and push for the adoption and execution of national policies by taking appropriate measures to control the excessive use of private vehicles. Mustafa and Najib (2008) stated that institutions suffer from many problems at the level of institutional building, and reported a lack of co-ordination between the authorities responsible for the implementation of environmental laws, while El-Fadel and Bou-Zeid (1999) stated that there is an urgent need for increased support and strength for the institutions responsible for pollution control, enable them to take action to control air quality.

Lastly, what can be gathered from the evidence reviewed above regarding the role of the Environment General Authority in addressing the problem of air pollution caused by cars is that the EGA is the only legal authority responsible for implementing the provisions of the environment law, including issues related to air quality and protecting the atmospheric air from air pollutants emitted by vehicles. These competencies have been defined by the Act and decision No. 236 of 1999 of the EGA's establishment. Most of the evidence has confirmed that the EGA has not performed its tasks in the field of addressing the problem of air pollution from cars, and has identified some actions which the authority should take to address the problem but has not done so; the most important of these procedures include:

i. Develop an action plan to reduce the problem of air pollution caused by cars.

ii. Establish fixed air quality monitoring stations in the city.

iii. Provide awareness programmers for citizens on traffic air pollution issues.

iv. Measure the concentrations of air pollutants emitted by vehicles.

v. Publish studies and research on air pollution from cars.

The evidence obtained from the EGA interviews suggested that the authorities have attempted many activities and actions on the subject of air pollution, within the constraints of its human capacity and technical knowledge. However, the EGA cannot accomplish many of the assigned tasks due to a lack of human potential, technical knowledge and necessary financial support from the government.

What can be understood from the evidence mentioned above is that EGA, the higher responsible authority on air pollution emitted by cars, has departments assigned to following up this issue, but they are unable to carry out all of the tasks related to traffic air pollution, due to the lack of human capacity and equipment.

Thus, it can be concluded that the EGA did not play the required role in addressing the problem of air pollution caused by cars, for a variety of reasons which, will be discussed in the next section.

8.6.1.1.1. Obstacles and difficulties facing EGA

The evidence from the questionnaire shows that the majority of respondents stated that there are obstacles and difficulties facing EGA in terms of reducing the air pollution caused by motor vehicles in Tripoli. These obstacles and difficulties were explained by the interviewees from EGA, who pointed out that the most serious difficulties included a lack of governmental financial support, technical obstacles such as severe shortages of equipment, instruments and air quality monitoring systems, and administrative difficulties such as a lack of staff and experts qualified to carry out the required actions to address the air pollution problem caused by vehicles. The perceptions of the EGA respondents concerning the difficulties facing EGA can be summarized as the following points:

i. Lack of government support for the EGA.

ii. Lack of technical capacity in the field of studies and research into air pollution issues.

iii. Lack of required equipment and laboratories to measure the concentrations of pollutants

iv. Lack of a monitoring and control system for air quality

v. Lack of coordination with the relevant authorities in the city.

The information gathered during the field visit to the General Authority for the Environment and referred to in the annual reports indicates that the EGA faces many difficulties that prevent it from performing its tasks. The EGA lacks technical knowledge in the field of traffic air pollution issues; it also does not have the necessary equipment to measure and monitor air pollution. In addition, the EGA has not received the necessary financial support from the government to suggest and implement the projects and programmers needed to address the problem of traffic air pollution. The information obtained indicates that the authority is not independent, as it belongs to the Ministry of Health, and so is unable to force ministries and institutions to implement its recommendations and suggestions. This, in turn, reduces their ability to enforce environmental law, including air pollution issues.

The national environmental law authorized the EGA to perform significant tasks, including the protection of air quality from motor vehicles, which can be summarized as the following points:

i. Conduct periodic measurements of the air pollutants emitted from vehicles.

ii. Make the necessary amendments to the Environmental Protection Act and develop standards for concentrations of pollutants.

iii. Provide the necessary equipment for the analysis of pollutants.

iv. Train and rehabilitate technical staff.

v. Provide the necessary means for raising public awareness about the risks of air pollution caused by cars.

vi. Conduct studies, research and environmental surveys of the sources of air pollution.

vii. Implement the Environmental Protection Act.

However, it is clear from the evidence discussed above that the current situation of the EGA does not qualify it to play the required roles because it lacks many of the tools and instruments and much of the equipment necessary to perform its tasks

8.6.1.2. The role of the GTL

The evidence from the questionnaires shows that most of the respondents stated that GTL has not taken effective action in terms of traffic management in the city. The majority of GTL respondents stated that the GTL is responsible for performing all of the required procedures in order to implement traffic law 11/1984, which include managing the traffic on the roads and checking the requirements for vehicle safety in addition to issuing driving licences and the procedures for vehicle registration. However, when the interviewees from GTL were asked about their capability to perform their tasks, the majority confirmed that GTL is suffering from a lack of qualified traffic police, and no intensive courses are provided. They all confirmed that the department of traffic police does not apply new technology to manage traffic congestion on the road network. The majority of GTL respondents indicated that the traffic police do not conduct vehicle engine tests, as these require instruments and equipment which are unavailable as well as need qualified people. Most of the GTL respondents confirmed that the institution suffers from several difficulties, including a lack of funds from the government, insufficient instruments and technology needed to monitor traffic congestion and conduct technical inspections of vehicle engines, a lack of intensive training, and an absence of knowledge about air pollution problems caused by vehicles.

The information from the direct observations suggests that there is an insufficient number of traffic police to cover the entire road network in the city, and that the GTL does not have the appropriate technology to manage the traffic on the road network. It lacks the devices and technical personnel trained to conduct engine performance tests.

Finally, according to all of the evidence reviewed above, GTL potentially makes an important contribution in relation to air pollution caused by vehicles: its roles include the implementation of the traffic law and control of pollution emissions by vehicles, in addition to its role in managing traffic on the road network in order to minimize the severity of traffic congestion: this role could contribute greatly towards reducing the amount of pollutants emitted by cars. The evidence from direct observation, however, suggests that GTL is suffering from a lot of difficulties due to a lack of financial support, which makes it unable to carry out its duties as required. These difficulties include the lack of qualified traffic police and lack of equipment and advanced technologies to control and manage the intensity of traffic congestion on the road network. Therefore, it can be concluded that the GTL needs financial and technical support and coordination and cooperation with the EGA in order to contribute towards addressing the problem of air pollution caused by cars.

8.6.2. The environmental law and relevant regulations

The laws and legislation on environmental protection and air quality play a major role in reducing traffic air pollution. The legislation provides instructions, directives and restrictions on human activities which may produce pollution, including motor vehicles. The environment laws contain rules and standards in order to protect air quality as a way to avoid health, environmental and economic effects resulting from damaged air quality.

Despite this potential, however, the questionnaire evidence indicates that neither the law on environmental protection nor the traffic law has the legal force to deal with the problem of air pollution caused by cars. The majority of those who participated in the questionnaire believed that the implementation of these laws is incomplete. The interviewees from EGA confirmed that Libya has no air quality law; the first national environmental law, issued in 1982 and amended by law 15/2003, deals with all environmental issues, including air pollution caused by vehicles, which are covered in the second chapter of the law under the heading “the protection of the atmosphere”. The respondents thought that the national environment law is unsatisfactory since it suffers from a lack of technical aspects, particularly regarding the control of air quality. The respondents from EGA confirmed that national standards for concentrations of air pollutants emitted by vehicles were unavailable in previous years, so regional and international standards were used, such as Arab and European standards and those of organisations including WHO and UNEP. The respondents from GTL were asked about the law on traffic on the road network: the majority of respondents stated that, although the law was issued many years ago, it can be considered as acceptable for managing traffic on the the road network, but needs to be developed and revised, with the addition of articles on air pollution caused by vehicles, which should include the testing of vehicle engines. The respondents confirmed that the traffic law had not been effectively implemented.

The evidence derived from direct observations shows that Environmental Protection Law No. 7 of 1982 was amended by Law No. 15 of 2003, but that these amendments had not undergone substantial changes regarding air quality issues, and that Law 15/2003 suffers from similar weaknesses to its predecessor, particularly with regard to the standards and criteria for pollutant concentrations, as well as the mechanisms for monitoring and controlling air quality. There are no national standards for air pollutants resulting from vehicles and so it is common to use the standards of Arab and European countries, as well as those issued by the WHO and UNEP. A draft proposal on air pollutant standards was issued by the EGA in 2005, but it covered only two pollutants, hydrocarbons and carbon monoxide, and had not been approved as the standards for air pollution. The traffic law regarding the conditions of vehicle safety and traffic on the road network does not contain conditions about the efficiency of vehicle engines and vehicular emissions standards. Documents referring to imported vehicles showed that conditions are set relating to safety and vehicle age, but there are no provisions on the efficient performance of vehicle engines or conditions about fixing catalysts or specific concentration of pollutants that can be emitted by imported cars. In addition, there are no requirements/conditions places on the kind of fuel consumed by vehicle engines.

The lessons from previous studies confirm the importance of legislation and national laws in reducing air pollution caused by cars, which can be inferred from the statement by El-Fade and Bou-Zeid (1999), who noted that the implementation of standards for concentrations of air pollutants will reduce these pollutants. Park (2005) mentioned that several countries have issued legislation and specific standards for the concentrations of emissions emitted by vehicles. McKeown (2007) stated that, although strict laws have been passed to reduce air pollution caused by vehicles, field studies have confirmed that the effectiveness of these laws was not at the required level and that further measures and actions need to be taken. Also, Mustafa and Najib (2008) stated that the environmental legislation in Arab countries is generally weak in most of its articles.

Lastly, according to all of the evidence explored above, the laws and legislation on air pollution caused by motor vehicles in the study area are limited, and contain many technical and administrative deficiencies. Technical shortcomings include a failure to specify standards for the concentration of traffic air pollutants and the absence of technical requirements which guarantee air quality. The enforcement of a local law on air quality is weak due to several factors, including a lack of technical and legal capacity to follow up issues related to violations of the law. The government does not have a special court for environmental issues; there are no national standards for vehicle emissions and the articles relating to air quality issues are weak. The creation of standards relating to concentrations of air pollutants is required in order to achieve a reduction in these pollutants. Many countries have issued specific criteria for concentrations of pollutants emitted by cars, but Libya still has no air pollution standards and needs to issue such standards to address the problem of air pollution caused by vehicles.

8.6.3. The actions which have been taken to reduce air pollution caused by motor vehicles

Many countries have taken a number of preventive and curative measures aimed at resolving the problem of air pollution caused by cars. The aim in asking about the actions which had been previously taken by the government and institutions to address traffic air pollution is to define these actions and assess whether they are effective in addressing the problem or even reducing it. This, in turn, will help the researcher to devise some recommendations for developing and improving these actions.When asked about the actions which have been taken to address the problem of air pollution caused by vehicles in Tripoli, most of the respondents to the questionnaire suggested that no such actions have been taken in the past. In contrast, the evidence from the interviews shows that some actions have been taken by the government and concerned institutions in order to improve the situation regarding air pollution caused by vehicles, but that these actions have not proved very effective in reducing or addressing this problem. The EGA respondents mentioned some actions that have been taken, which include an amendment to environmental law 7/1982, the creation of conditions for importing vehicles, improvements to the road network, and the ban on the use of leaded fuel since 2004.

The evidence obtained through direct observations showed that the amendments made to law of 7/1982 by law 15/2013 did not make any change to the chapter on the protection of the atmosphere. The number of items (eight) remained the same, and only two related to air pollution caused by cars, which is the same as in the Act of 1982; there was no specific law regarding air quality. Although a ban has been imposed on the use of leaded petrol since 2004, petrol and diesel, which are polluting fuels, are still in use, and there has been no move towards the use of clean fuel, such as compressed liquid gas. The EGA does not have the administrative competence to control air quality and follow up the traffic air pollution issue. The Department of Pollution Control has five sections and four technicians who are university graduates, but there are no special courses for increasing their skills in the field of air quality monitoring, leading to the inability of these departments to deal with traffic air pollution.

The evidence from the literature review confirms that many countries have taken action to resolve similar problems. For example, Ackchai et al.(2006) stated that many governments have taken measures to reduce the negative effects of pollutants emitted by vehicles, including preventing the use of leaded fuel, controlling air quality through improved engine technology such as the catalytic converter, adopting the measures and procedures which have worked in several countries, and setting standards and criteria to determine the concentrations of pollutants emitted and reduce the rate of sulphur content in motor fuel, in addition to controlling and regulating movement on the roads, preventing traffic congestion and facilitating vehicular traffic. Governments must push for the promotion of policies, plans and programmes that lead to the protection of air quality through establishing programmes regarding the rational use of energy and the transition towards the use of clean energy fuel for transport (Ozden, 2008).

Finally, according to the evidence mentioned above concerning the actions taken by the government to address the problem of air pollution caused by cars in the study area, it is noted that the actions were not implemented as a programmed or strategy. Some actions were carried out randomly and without coordination between different relevant sectors which have made these actions limited in terms of quantity and quality and reduced their impact on the problem. The amendment of the Environmental Protection Act did not bring about a fundamental change in the law regarding the protection of air quality monitoring and the actions regarding the use of fuel in car engines. The evidence confirms the absence of any projects regarding the use of cleaner fuels in car engines. There are has been no improvement in public transport, which has remained underdeveloped and entails only taxis. In addition, the official body responsible for air quality management still lacks the necessary tools and human resources;

the evidence indicates that the measures taken are inadequate due to a lack of attention to the traffic air pollution problem and insufficient support for the concerned institutions. This has constrained their ability to take the required actions to address the problem of traffic air pollution caused by vehicles.

8.6.4. Relevant policies for addressing air pollution caused by motor vehicles in Tripoli

The respondents were asked about the availability of plans, projects and programmes to manage air pollution caused by vehicles. The majority of the respondents to the questionnaire stated that the responsible authorities have no relevant policies, plans or programmes for reducing air pollution in the city. The EGA interviewees mentioned that the EGA has already proposed and adopted an action plan to improve the environmental situation in Libya. The plan, named the "National Programme for Environmental Improvement 2006-2011", contains many projects, including the monitoring and control of air quality. The air quality monitoring project includes training, a survey of air pollution sources, the creation of a database on air pollutants and the establishment of an air quality monitoring system. The project has not been implemented, however, because of an absence of financial support for it.

The evidence from direct observations and documents collected from the Environment General Authority showed that the National Programmed for Environmental Improvement 2005-2011 included a section on atmosphere pollution. The cost of the programme was 900 million Libyan dinar (approximately £0.5 billion). The project has not been implemented until now because of the lack of financial support from the government. In 2010, a mobile lab was imported to measure air pollutants emitted by cars in the city centre for the period from July 21 to 27 2010 (see Chapter 5).In addition, the information gathered from reports issued by the planning ministry indicated that there is a project for improving the road network through implementing the third phase of a ring road. This project is still under construction and is expected to be completed in the coming years. Based on the policy objectives of land transportation in Tripoli, there was a proposal to set up a city train service, which will contribute towards reducing traffic congestion and the risk of accidents as well as providing safe transportation. The project was proposed during the 1990s, but has not yet been implemented, and now the government is considering the possibility of its implementation in the coming years.

The evidence from the literature review confirms the importance of action by governments to solve the air pollution problem. For example, Ozden (2008) stated that governments and institutions must push for the promotion of policies, plans and programmes that lead to the protection of air quality. Also, Devis et al. (2006) mentioned that action on air pollution in developing countries needs to consider that motor vehicles are having greater effects on health, and that these countries need to address this issue by developing rapid and necessary measures to solve this important environmental problem as part of air quality projects.

Finally, the evidence outlined above shows that insufficient attention has been to traffic air pollution in the study area and that there is a general agreement that the changes made to the environmental protection law had no impact regarding the issue of traffic air pollution. The evidence also confirmed the absence of any projects related to the use of cleaner fuels in car engines, including the use of compressed liquid fuels which are produced in Libya. Also, there has been no improvement in the public transport sector, which includes only taxis. Also, the authorities responsible for air quality management have not developed their facilities or human resources. The evidence indicates that the actions taken so far were insufficient due to a lack of government interest in air pollution caused by cars and a lack of support from the concerned institutions, rendering them unable to propose and implement plans and strategies to address the problem.

8.7. Findings related to the increasing reliance on private vehicles.

The vehicle fleet can be simply divided to the private vehicles and public transport and their respective classifications in terms of types and sizes. This study looked at the size of the vehicle fleet in the study area to find out the extent of reliance on private vehicles and public transport, and to investigate the trends of the citizens regarding the use of both kind of transport.

8.7.1. Decrease of reliance on private vehicles for travel

The respondents were asked why people should reduce reliance on private cars. The majority of those who answered the questionnaire recommended that people should reduce their reliance on private cars for travel because that could contribute towards reducing the amount of air pollution resulting from fuel combustion in car engines and thus decrease the air pollution caused by vehicles. The majority of interviewees suggested that individuals should reduce their reliance on private vehicles for travel, and should be encouraged to use public transport in the city; public transport is considered a significant contributor in addressing the air pollution problem caused by vehicles, because such action can serve to reduce the great quantities of fuel consumed as well as traffic congestion, and as a result reduce the total emissions from vehicles. The interviewees believed that people should change their behaviour in terms of using private vehicles and rationalizing the fuel consumed by their vehicle's engine.

The evidence derived from direct observations shows that the size of the private vehicle fleet in the study area has dramatically increased, from 4,851,36 vehicles in 2005 to 5,641,82 vehicles in 2006 at an annual rate of increase of 16.29%. In 2010, the total private vehicle fleet consisted of 809,815 vehicles, giving an annual average increase rate of 15.30%. The average number of vehicles per capita for the period 2005-201 Owas 762 vehicles/1000 persons. Some vehicles were old models, sold at low prices, which enabled people to afford private vehicle, and so increased the ownership of private cars. The use of private vehicles is widespread in the city.

Most of the evidence agreed that reducing the reliance on private transport is a significant measure that must be taken in order to develop any strategy for addressing the problem of air pollution resulting from vehicles in the city. Therefore, it is vital to think seriously about how to reduce the excessive increase in the reliance on private vehicles in the study area. The majority of evidence suggests that a decreased reliance on private vehicles for travel in the city would make a significant contribution towards reducing the air pollution problem caused by traffic and its negative effects on health, the environment and the economy.

8.7.1.1. Achievement of a reduced reliance on private vehicles for travel

The respondents to the questionnaire believed that private vehicles are important for people; most of the respondents supposed that private vehicles are important for travelling to work, taking children to school, visiting family and shopping. The respondents suggested that actions to overcome the increasing reliance on private vehicles for travel in the city should include placing increasing controls on the import of cars and developing the technical requirements for imported vehicles, as well as supporting the public transport sector to encourage citizens to use it, raising the price of fuel used in cars, and increasing tax on imported vehicles.

The evidence from the interviews followed the same trend; the respondents suggested that the actions which should be considered for overcoming the increasing reliance on private transport in the city include identifying and addressing the main reasons that lead to the reliance on private cars for travel, developing the conditions for importing cars, raising customs fees on imported vehicles, and preventing the import of old vehicles. The respondents added that the price of fuel should be increased and public transport services should be improved; also, there was a need to concentrate on raising public awareness of the significance of reducing the reliance on private vehicles in order to address the problem of air pollution caused by vehicles in the city. The direct observations indicate that people own cars as that is part of the social culture and because of the lack of public transport infrastructure; car ownership is considered a priority, and if people are to reduce their reliance on private vehicles, alternative means of public transport need to be provided. The evidence from direct observation also shows that the public transport sector in Tripoli is lacks the necessary infrastructure, and needs further development in order to encourage people to reduce their reliance on their own vehicle for travel in the city.

Such thinking is in line with previous studies; For example, Gorham (2002) stated that controlling the air pollution caused by vehicles could include reducing the reliance on private cars while at the same time improving the public transport and service sector: otherwise, there will be a large-scale expansion of the use of private cars. Faiz et al. (1996)agreed that stopping the growth in the use of the vehicles provides economic, health and environmental advantages. Orlando (2009) suggested that limiting the age of imported vehicles should be a way to reduce the import of vehicles, and could contribute towards controlling air pollution resulting from the increase in the number of private vehicles.

The evidence discussed above confirms that the private transport sector represents the majority of the vehicle fleet in the city and that there are many factors which contribute to people's increasing reliance on private cars. However, there is an agreement that many steps can be taken to reduce reliance on the private travel in the city, including reducing the size of the private vehicle fleet by imposing regulations to reduce the import of cars from abroad, such as raising the tax on imported vehicles, setting and informing technical standards for vehicle engines as well as developing the public transport sector and improving its infrastructure in order to provide high quality services which are acceptable to people, to encourage them to decrease their reliance on their own vehicle. Raising the cost of fuel could be another strategy.

8.7.2. The public transport sector in the city

The public transport fleet in the study area represented only 5-6% of the total vehicle fleet in the city, and is limited to taxis and light and medium-sized buses only.

The evidence from the questionnaires regarding the respondents' use of public transport showed that 12.5% always used public transport, 57% did partly and 30.4% never did. In the interviews, all of the ATD interviewees agreed that the public transport vehicle fleet in Tripoli consisted of taxis and minibuses. There were fewer public transport vehicles than required to provide a good quality service and cover all areas of the city, which caused many difficulties and obstacles. The GTA respondents confirmed that many people use public transport to travel in the city, in spite of the high numbers of private vehicles. Also, the people coming from the surrounding areas to the city use public transport for shopping and other purposes in the city. In addition, some people who have a private car prefer to use public transport due to a lack of sufficient parking in the city centre and the fear of vehicle theft, particularly in some public areas.

The evidence derived from direct observations confirmed that the public transport sector in the study area contains only taxis and small/medium-sized buses. No other means such as trains and trams, were observed, nor were there any means of free transportation in the city centre. Despite the heavy reliance on private vehicles, public transport is widely used, especially by students, but is not available in sufficient numbers to transport passengers to all areas of the city. Most of the government institutions provide buses to transport their employees. According to data gathered from the DVR, the public transport sector represents 5-6% of the total vehicle fleet in the city. Most people believe that this sector offered a great service, especially for students, but needs good management, better organization and new vehicles, as most taxis and minibuses are old and uncomfortable.

The literature attests to the benefits of public transportation, including reducing energy consumption and environmental pollution. Gwilliam et al. (2004) stated that using of public transport for travel results in less fuel consumption and fewer pollutants being emitted per passenger-kilometre. Watkiss et al. (2004) agreed that one way to reduce emissions would be to improve the public transportation infrastructure. Shapiro et al. (2002) similarly saw the use of public transportation as extremely significant for reducing energy consumption and environmental pollution. Similarly, Sarath et al. (2003) suggested trams, buses and public taxis as a solution to the problem. Gorham (2002) viewed the transport sector as one of the main components of an air quality strategy, the main objectives of which should be improving public transport and services and encouraging people to use it, rather than continuing to depend on private transport. Walking, "zero- carbon" projects and cycling are all effective alternatives that should be taken into account in order to reduce the amount of pollution caused by cars (Sarath et al. 2003).

To summarize, the above-mentioned evidence about the public transport fleet in the study area agrees that the use of public transport is still limited, with its main consumers being students, due to the low prices. Public transport represents only 5-6% of the total vehicle fleet is subjected to many difficulties and obstacles and lacks the capability to provide a high quality service for passengers. The majority of evidence above confirmed that the public transport sector in the city fails to meet the required criteria and needs to be developed by improving the infrastructure and including other means such as trams, trains and large-sized buses, which are currently unavailable, as well as providing free buses in the city centre, in order to reduce the severity of traffic congestion on the road network.

8.8. Findings related to the available options for addressing air pollution caused by motor vehicles

The air pollution resulting from motor vehicles has greater effects on health in developing countries and needs to be addressed by undertaking the required actions (Devis et al.2006).Many countries have taken several appropriate actions to address the problem of traffic air pollution and these actions include several legal and administrative aspects as well as development of capacity building and public transport means. In addition, the use of unpolluted fuel in vehicle engines has been encouraged.

The respondents were asked about their perceptions of the available options for addressing air pollution caused by vehicles. The evidence obtained from the questionnaire shows that most of the respondents believed that the main available options for addressing the problem of air pollution caused by cars include improving vehicle technology, developing fuel technology, improving the national environmental laws, supporting the authorities responsible for air pollution issues, developing the public transport sector, raising public awareness on air pollution issues and improving the management of traffic congestion.

The evidence from the interviews shows that the majority of the interviewees believed that the most important of the available options is to identify and resolve the factors that contribute to the existence of the problem. The options could include improving vehicle technology and producing clean fuel, as well as developing environmental legislation, particularly in terms of air quality, developing the public transport infrastructure, improving the management of traffic congestion, and providing the required support for the concerned authorities, particularly the EGA, to enable them to manage and control the air pollution caused by vehicles. The interviewees also highlighted the importance of raising public awareness on the issues of air pollution caused by vehicles, which must be considered as one of the options for resolving the problem.

The evidence gathered through direct observations showed a lack of application of vehicle technology; no technical examination is carried out to measure the concentrations of vehicular emissions, and there are no arrangements for fixing catalytic converters. Also, the fuel used in cars is gasoline and diesel fuel, and there has been no development of fuel technology and no programmes to transform vehicles to use clean fuels such as compressed liquid gas and hydrogen, although Libya is a large producer and exporter of natural gas.

The evidence from the literature review supports most of the available options; for example, Park (2005) stated that vehicle technology, including improvements to engines to increase fuel burn efficiency, will help to reduce the emission of pollutants. Gorham (2002) added that there is an urgent need to consider public transport management, which is one of the most important issues for reducing the pollution caused by vehicles. Gwilliam et al. (2004) suggested that the types of alternative fuel include gaseous fuel, bio fuel, and electricity, while El-Osta and Zegham (2000) recommended that such technology can be applied in Libya. Bickersta and Walker (2001) showed that there is a need to develop public awareness about the problems of air pollution caused by cars by producing publications, brochures and other media. Gwilliam et al. (2004) indicated that a traffic management system is required and will offer advantages including reducing vehicle emissions and fuel consumption.

Therefore, based on the evidence which has already been presented and discussed in the previous section, the most important options available for addressing the problem of air pollution caused by cars in Tripoli are as follows:

i. Improving vehicle technology

ii. Developing fuel technology

iii. Developing national environmental laws

iv. Supporting the responsible authority on air pollution issues

v. Developing he public transport sector

vi. Raising public awareness on issues related to air pollution caused by vehicles

vii. Developing traffic congestion management.

8.9. Findings related to the management strategy and instruments required to reduce the air pollution caused by motor vehicles in Tripoli

8.9.1. Management strategies for reducing air pollution caused by motor vehicles in Tripoli

The respondents were asked about their perceptions of the need to develop a strategy to reduce air pollution caused by vehicles in Tripoli. The evidence from the responses to the questionnaire indicates that the majority of the respondents believed that the current status of air pollution from motor vehicles in the city necessitates the development of an environmental strategy to address the problem.

In the interviews, most of the respondents from the EGA expressed the view that the current situation regarding the traffic air pollution problem in the study area requires a lot of actions to reduce it through creating a national strategy. The EGA respondents suggested that the strategy should include an evaluation of the current status of air quality and thus the development of an action plan to be implemented in several phases, as well as involving all of the concerned sectors and the provision of the financial funds needed to implement the strategy. This is what was agreed by most of those interviewed from GTL, who suggested that the strategy should include the provision of support for the police traffic through training and supplying the required instruments for traffic management.

The evidence gathered from the direct observations provided many indicators that Tripoli is suffering due to air pollution caused by traffic. The emissions inventory 2005-2010 confirmed that the amount of vehicular emissions has increased. The information gathered from the EGA reports indicated that the EGA does not have a strategy in place for addressing the problem because of the many difficulties previously discussed.

The evidence from the literature review confirms the necessity of introducing a strategy in order to address the problem of air pollution caused by vehicles. For example, Komjim and Love (2001) mentioned that the most important factors in developing a strategy to reduce air pollution resulting from motor vehicles should include the identification of the most important environmental problems, estimates of the potential damage to public health and the environment, and the choice of a suitable strategy, taking into consideration the institutional and legislative infrastructure and human capacity as well as financial budgets, and acting in cooperation with all relevant sectors.

The evidence discussed above confirms that the situation of air pollution from cars in Tripoli necessitates the development of a comprehensive strategy to address the problem, and the responses have suggested that the strategy should involve all relevant sectors and have a specific time frame and several phases. The responses have recommended some relevant measures which could be included in the proposed strategy, such as the development of relevant environmental laws, the improvement of vehicle technology and fuel technology, training and rehabilitation, in addition to the development of the public transport sector and the raising of public awareness on traffic air pollution. It is clear that, currently, there is no national strategy on air quality and air pollution caused by cars, which shows the importance of creating a strategy to address the problem of air pollution caused by cars in the city.

Finally, it can be understood from the evidence mentioned above that the problem of air pollution caused by cars in Tripoli essentially requires further study and investigations in order to inform a comprehensive strategy to address the problem, prevent exacerbation and mitigate potential damage such as risks to health, the environment and the economy.

8.9.2. Instruments required for developing a strategy for the management of air pollution caused by motor vehicles in Tripoli

In order to identify the instruments which need to be provided to develop a strategy for the management of air pollution caused by cars in Tripoli, the respondents were asked about such instruments. The majority of the respondents to the questionnaire agreed that the instruments required included technical, institutional, economic and social instruments, in addition to plans and policies. The information obtained from the interviews indicates that most of those who were interviewed from EGA stressed the importance of providing some necessary instruments for the implementation of a strategy to address the problem. They suggested that the preparation and implementation of a strategy requires the provision of three kinds of tool and instrument: legal, institutional and financial support. Legislative measures would provide strategy with the legal power to make the institutions and people adhere to all of the recommendations that may be issued for its implementation. The required institutional measures are related to the creation and development of the relevant institutions so that they can implement various stages of the strategy, while the economic measures aim to provide the necessary funds for the implementation of every phase of the strategy.

The GTL respondents supported what the EGA respondents said. They stressed the need to provide financial support for all relevant sectors, including the GTL. They suggested that the instruments should include the provision of training, rehabilitation, equipment and advanced technology to manage the traffic on the road network, in addition to increasing the knowledge and awareness of environmental issues among the traffic police.

From the evidence gathered from the interviews, it is noted that the interviewees have suggested that the instruments needed to develop management strategies for solving the air pollution problem caused by vehicles in Tripoli are as follows:

i. Involving all relevant sectors in the strategy, including the environment, transportation, finance, planning and traffic police sectors

ii. Providing legal, institutional and financial aspects to implement the strategy

iii. Identifying a time frame for the various strategic stages

iv. Providing training, rehabilitation, equipment and advanced technology for the institutions involved as part of the strategy.

The evidence from the direct observations shows that the EGA and other concerned authorities in the city lack a strategy on air pollution caused by vehicles because of the shortage of human resources, and that facilities need to be provided for such institutions so that they can create such a strategy. Therefore, there is a need to provide human and financial support to develop and implement a strategy to reduce air pollution caused by cars in the city. It is noticed that there is a weakness in the building of institutions and human capacity, so further development is required in this direction.

The evidence from the literature review confirms the need for the provision of instruments to create a strategy; for example, DEFRA (2007) stated that strategies for air quality management in cities require a clear action plan for the short, medium and long term, and this plan should determine a time frame which should make it clear what will be managed and implemented in each of the stages.

What can be understood from all the evidence is that one of the most important tools needed to create a strategy is the capability of the concerned authorities to prepare and implement a strategy. However, the evidence shows that, currently, the human capacity is limited because the EGA does not have the capability, qualified staff, equipment or tools required to create and implement a strategy to address the problem. Also, the current environmental law needs to be amended to provide legal support for the strategy.

Finally, all of the evidence agrees that there is serious need to provide many necessary instruments for the establishment of a strategy to address the traffic air pollution problem in Tripoli, which are not yet available, including legislation, institutional, and financial measures, as discussed above.

8.10. Chapter Summary

This chapter has reviewed all of the measures related to the topic of the study, through discussing the evidence gathered from the various sources of data, including questionnaires, interviews, direct observations and previous studies.

A cross-referenced table was presented to give a summary of the evidence from four sources: questionnaires, interviews, direct observation from fieldwork, and the literature review.

The findings from the questionnaire, interview and fieldwork observation were compared with the corresponding evidence obtained from the literature review, to investigate the problem of air pollution caused by vehicles and the factors which have led to this problem.

Most of the evidence from the questionnaire, interviews, direct observations, and previous studies suggest that there are health, environmental and economic effects in the city of Tripoli resulting from air pollution caused by vehicles.

The laws and legislation on air pollution caused by motor vehicles in the study area are limited, and weaknesses in technical and administrative aspects have led to a failure to identify the concentrations of traffic air pollutants and an absence of technical requirements to guarantee the air quality.

Actions mentioned by the respondents that might reduce the reliance on private cars in the city include raising taxes on imported vehicles, controlling the technical requirements for imported vehicles, improving public transport, encouraging the citizens to use it and raising the price of fuel used in cars.

The chapter concluded that the situation regarding air pollution caused by cars in Tripoli necessitates the development of a comprehensive strategy to address the problem, and the respondents suggested that this strategy should involve all of the relevant sectors and have a specific time frame and several phases. All of the data and information presented in this chapter will be employed in the theoretical framework to test various scenarios in order to evaluate the air pollution caused by vehicles in Tripoli, which will be presented in the next chapter

Chapter Nine

Utilisation of the framework to test various scenarios for the evaluation of Air Pollution caused by Vehicles in Tripoli, Libya

9.1 Introduction

The aim of this chapter is to present various scenarios for the evaluation of the status of air pollution caused by motor vehicles in Tripoli. The different scenarios will assist the government, local authorities, and institutions to understand the actual level of the problem in current and future years. In addition, they will provide the opportunity to apply different options for controlling the factors affecting the problem, addressing it, and mitigating the health, environmental, and economic effects resulting from air pollution caused by motor vehicles.

A framework was developed to evaluate air pollution caused by vehicles in the city of Tripoli, as described in Chapter Two (section 2.10).For the purpose of testing various scenarios regarding the status of air pollution emitted from motor vehicles, it is necessary to employ and take advantage of the framework components and structure. This has been modified to suit the issue of air pollution from motor vehicles based on the data and information provided by the framework.

Multiple stages have been adapted for the purpose of providing and testing the scenarios with regard to air pollution. The first phase of the framework provided different parameters which were utilised to test the changes in air pollution status with time. Varying parameters, including the number of motor vehicles and the amount of consumed fuel, are shown in Figure 2.2, indicating potential changes in air pollution. Using the framework to test different scenarios also addressed the amount of pollutants released from vehicles over several years. A base line year was established to consider potential changes in the future. The review of the different scenarios relied on the assessment related to the proposed framework.

9.2. Description of the affecting parameters on air pollution caused by motor vehicles in Tripoli

The framework determined the main socioeconomic and institutional factors which have contributed to the occurrence of air pollution from motor vehicles in the study area. Other details about the affecting factors have already been covered in chapter Two (section 2.10).

The relevant factors were identified by the framework as shown in Table (9.1), together with the related parameters.

Table 9.1 Affecting Factors and Parameters

Affecting factors	Parameters
Economic factors	- Increase of private vehicles - Increase in fuel consumption
Legislation and institutional factors	- Lack of legislation - Lack of institutions
Social factors	- Growth of population - Lack of environmental awareness
Management factors	- Severe traffic congestion - Lack of public transport.

9.3. The various scenarios regarding air pollution caused by motor vehicles in Tripoli

The proposed framework was applied to evaluate the status of air pollution caused by motor vehicles in the reference year (2010). This was considered as a baseline year where the data obtained represented reliable and accurate data from the National Authority in Libya (DVR, 2010).In using the baseline year, the framework was applied to evaluate air pollution up to the predicted year of 2020. For this purpose, scenarios were selected to evaluate the expected status of air pollution caused by motor vehicles in 2020. The year 2020 was selected because, in Libya, the National Plan and System of operation is managed over a five year period. This provides the National Authorities with sufficient time to create and implement their plans. The evolution of air pollution statutes in 2020 relates to the various scenarios and the changing parameters.

9.3.1. Emission Modelling Scenarios

The five scenarios are as follows:

1. The first scenario represents the baseline scenario, or "no change scenario", which presents and describes the actual status of air pollution caused by vehicles in Tripoli for the reference year (2010). In addition, the vehicular emissions in 2010 were calculated by the modelling of emissions (covered in Chapter 5), which was considered to be the baseline year, representing the actual current status of air pollution caused by motor vehicles. The parameters applied in this scenario were the actual vehicle fleet size and the corresponding quantities of fuel consumption.
2. The second scenario addresses the current situation regarding air pollution from motor vehicles in 2010 up to2020 under the same conditions. Consideration was paid to the vehicle fleet size and consumed fuel. It was assumed that this will increase at the same

annual rate as in the reference year (2010). This scenario does not consider any additional measures to improve the status or any modifications that are applied between 2010 and 2020.

3. The third scenario is based on the government and relevant institutions carrying out the recommended actions required to address the problem of air pollution in order to mitigate the situation in future years. The scenario examines improvements from 2010 of an implemented alternative, as identified in the framework, to address the causes of air pollution resulting from motor vehicles. This specifically relates to vehicle technology improvements through the fitting of catalytic converters.
4. The fourth scenario addresses improvements in fuel technology and the realised efficiencies through the decrease in fuel consumption.
5. The fifth scenario also considers improvements in fuel technology, but more specifically the reduction in the sulphur content of the fuel consumed.

The five scenarios are shown in Figure 9.1. The use of the selected scenarios was designed to make it possible to determine the effect of each element without the influenced of other factors. The assessment of the different scenarios was kept independent in order to identify the most influential factors on increasing or decreasing the amount of pollutants from motor vehicles.

9.3.1.1 First scenario (baseline year 2010)

The baseline scenario presents and describes the actual status of air pollution caused by motor vehicles in Tripoli for the reference year (2010), through the use of data provided by the Libyan National Authority. The parameters tested in this scenario were based on the vehicle fleet size and the corresponding fuel consumption. Other factors affecting air pollution caused by motor vehicles remained the same, without any changes.

Scenarios for Modeling Emissions

First Scenario

Base-line scenario (year 2010) representing 'no change'

Scenarios up to the year 2020

Second Scenario	**Third Scenario**	**Fourth Scenario**	**Fifth Scenario**
Based on an increase in the size of the vehicle fleet	Based on improvements to vehicle technology and the fitting of catalytic converters	Based on improvements in fuel technology and a decrease in the amount of fuel consumed	Based on improvements in fuel technology and a decrease in the sulphur content of fuel

Figure 9.1 Emission Modelling scenarios and parameters

The data and information gathered and analysed in this study showed that, in 2010, the total size of the vehicle fleet in Tripoli was 1,022,653 vehicles. The number of the different types of vehicles are shown in Table 9.2.

All of the different types of motor vehicles in the city use gasoline and diesel fuel. The fuel consumption in Tripoli for 2010, as provided by the Libyan National Authority, is shown in Table 9.3.

Table 9.2 Vehicle fleet size for the first (baseline) scenario

Type of vehicles	Year 2010	Percentage representation
Private vehicles	809,815	79.19
Public Transport (Taxis)	51,657	5.05
Light-duty vehicles	129,407	12.65
Heavy-duty vehicles	31,774	3.11
Total vehicle fleet	1,022,653	100.00

Table 9.3 Fuel consumption in Tripoli (2010)

Type of Fuel	Quantity of Fuel (Mt)	Percentage
Petrol	767,841	76.88
Diesel	230,911	23.12
Total	998,752	100.00

For the purpose of calculating the quantities of vehicle emissions for the first scenario (2010), COPERT 4 version 11 software was used. This was presented as a part of the framework (pressure indicator) for the emissions inventory in the city of Tripoli for the period 2005-2010. The details are summarised in Table 9.4.Table 9.5 also shows the limited speeds of the different types of vehicle. Using the COPERT software, the emissions of vehicles for the first scenario (baseline year 2010),previously presented in tables and figures in chapter five, are shown in Table 9.6.

Table 9.4 Summary of the data entered into COPERT software for the first scenario

Parameters required	Data entered
Vehicle fleet numbers	Private vehicles (809,815 vehicles), Light-duty vehicles (129,407 vehicles), Heavy-duty vehicles (31,774 vehicles), Public Taxis (51657 vehicles)
Fuel consumption types (Mt)	998,752 Mt (Petrol fuel 767,841 Mt, dieselfuel230911 Mt)
The sulphur content	The sulphur content mainly affects the calculation of the emissions of SO_2. The values of the sulphur content of petrol and diesel fuel are 150mg/kg and 0.08%, respectively, based on the National Standards and criteria (Code: LNCSM 495.2007)
Average temperature	The values of the monthly maximum and minimum temperatures for 2010 were obtained from the national meteorological centre in Tripoli
Reid vapour pressure (RVP)	Used to calculate the evaporation loss of petrol, as prescribed in Libya's national fuel standards (Code: LNCSM 495.2007). Minimum value 45, Maximum 70 kilopascal
Average speeds	The values shown in the regulations on the network traffic as shown in Table9.5
Annual mileage	Based on the consumption of approximately 12 litres of fuel to travel a distance of 100 kilometres, the annual mileage is calculated according to the total quantities of fuel consumed in 2010, as shown in chapter 2, Section 2.3, Table 2.2.
Emission regulation	Provided by COPERT Software
Emissions factors	Calculated by the software

Table 9.5 Limited speed for all types of vehicle in Libya

Types of roads	Urban road Km/hr	Rural road Km/hr	Highway road Km/hr
Private vehicles	50	70	100
Light and heavy duty vehicles	40	60	80
Public Taxi	30	50	65

Source: DVR, 2010

Table 9.6 Vehicle emissions for the first (baseline) scenario

Emissions (Mt)	Baseline scenario 2010
CO	41,051.96
VOC	3,728.66
NMVOC	3,337.78
NOx	9,846.55
NO	9,407.23
NO_2	439.32
$PM_{2.5}$	363.17
PM_{10}	535.84
$PM_{exhaust}$	142.35
CO_2	3,284,687.43
SO_2	449.85
Total	3,353,990.14

The first scenario describes the factors that influence the air pollution caused by motor vehicles. The outputs of the baseline scenario will be employed for comparative assessment with other selected measures concerning air pollution caused by motor vehicles in Tripoli.

9.3.1.2 Second Scenario 2020 (increase in vehicle fleet size)

The second scenario considers air pollution caused by motor vehicles in 2010 up to 2020, under the same conditions, with increases in vehicle numbers at the same annual rate, as in the first scenario (baseline year 2010).No additional measures were implemented to improve the status of air pollution in the period 2010-2020.The parameter assessed in this scenario was based on the changes in vehicle fleet size at the rate of increase from 2009 to the baseline year (2010).

Using the baseline scenario, and based on the annual rate of increase of the vehicle fleet size in 2010, the annual percentage change was calculated as follows:

% change =(v2 - Vi) / Vi x 100

Where Viwas the starting number of vehicles, and v2 the ending number of vehicles

% change = (1,022,653 - 954,921) / 954,921 x 100 = 7.09 %

The vehicle fleet size in Tripoli in 2020 was calculated using the annual rate and applying the general formula to calculate the future population given the current population and growth rate:

Pop_{Future} — $Pop_{present}$ X (1 + i)

Where:

$Pop_{Present}$ = Present Population

i = Growth Rate

n = Period

ThereforeVeh2o2o= veh20io x (1+ i)n

Where : n = the period (10 years)

i = the rate of growth (0.0709)

Veh2o2o = 1,022,653 x (1.0709)'°

Veh 202o= 2,028,698 vehicles

The calculation shows that the vehicle fleet will increase to 2,028,698 vehicles in 2020. Private ownership, which represents the largest number, will continue to increase to 1,606,479 vehicles, representing 79.19% of the total vehicle fleet. The details of the different types of vehicles are shown in Table 9.7.

Table 9.7 Vehicle fleet in the second scenario (2010-2020)

Type of vehicles	2010	2020
Private vehicles	809,815	1,606,479
Taxis vehicles	51,657	102,475
Light-duty vehicles	129,407	256,712
Heavy-duty vehicles	31,774	63,032
Total vehicle fleet	1,022,653	2,028,698

Using COPERT 4 software to calculate the emissions, data from the number of vehicles up to 2020 were entered, as shown in table 9.8 below.

Table 9.8 Data entered into the COPERT software for the second scenario based on the change in vehicle fleet numbers.

Parameters required	Data entered
Vehicle fleet numbers	The total vehicle fleet of 2,028,698 vehicles. Private vehicles (1,606,479 vehicles), Light-duty vehicles (256,712vehicles), Heavy-duty vehicles (63,032 vehicles), Public Taxis(102,475vehicles).

The COPERT 4 software was used for emission modelling in this scenario to identify the contribution of the increased vehicle fleet size as an affecting factor regarding the air pollution emitted from motor vehicles. Using the COPERT 4 software, the total emissions of vehicles in 2020 for the second scenario are shown in Table 9.9 below.

Table 9.9 Vehicle emissions based on an increase of vehicle fleet size, second scenario

Emissions (Mt)	Second scenario 2020 Increase in vehicle fleet size
CO	76,019.64
VOC	6,904.60
NMVOC	6,180.87
NOx	18,233.74
NO	17,420.22
NO_2	813.53
$PM_{2.5}$	672.52
PM_{10}	992.27
$PM_{exhaust}$	263.60
CO_2	6,082,553.50
SO_2	833.03
Total	6,210,887.52

Table 9.10 The change in vehicular emissions between scenarios, 2010 and 2020, based on an increase in the vehicle fleet size

Emissions (Mt)	Baseline scenario 2010	Second scenario, 2020 Increase in vehicle fleet size
CO	41,051.96	76,019.64
VOC	3,728.66	6,904.60
NMVOC	3,337.78	6,180.87
NOx	9,846.55	18,233.74
NO	9,407.23	17,420.22
NO_2	439.32	813.53
$PM_{2.5}$	363.17	672.52
PM_{10}	535.84	992.27
$PM_{exhaust}$	142.35	263.60
CO_2	3,284,687.43	6,082,553.50
SO_2	449.85	833.03
Total	3,353,990.14	6,210,887.52

The percentage increase in vehicular emissions from 2010 to 2020, based on the increase in the vehicle fleet size was 85.18%, as shown in Table 9.10.This increase in vehicle fleet size clearly reflects the increase in air pollution caused by vehicles, and represents a priority issue in any national or management strategy for addressing air pollution caused by vehicles.

Clearly, the resulting air pollution from motor vehicles will continue to increase unless action is taken to address this situation. Other options and actions, including the rationing of imported cars, would need to be assessed to address the problem. Additionally, the development of national environmental legislation, improvement in the infrastructure for public transport and increasing public awareness, together with other relevant actions, plans and programs, requires consideration.

9.3.1.3. The Third Scenario 2020 (Fitting Catalytic Converters)

The third scenario considers improvements in 2010, owing to the implementation of alternatives to air pollution provided by the framework.

In this scenario, improvements in vehicle technology were addressed based on the fitting of catalytic converter systems. This option was presented in the response phase involved in the structure of the framework, as shown in Figure 2.2. The fitting of catalytic converters can reduce air pollution through reducing the quantities of hydrocarbons, carbon monoxide, and nitrogen oxides.

In using the COPERT 4 software, data were used to calculate the emissions based on the fleet size from the second scenario based on the assumption that all vehicles had catalytic converter systems fitted, as shown in Table 9.11 below. In the COPERT Software, under the menu headed "Fleet Configuration", the user can find commands for configuring the vehicle fleet. One of these commands is:

Fleet Configuration > Edit >Technology

With this form, changes can be made through the "user defined" technologies by selecting the appropriate technology. These technologies are sorted into ascending order. The technology of fitting catalytic converter systems can be made in the properties tab "name textbox" and the change initiated. According to this selected technology, the COPERT software calculates the different emissions based on the fitting of catalytic converter systems to vehicles.

Emission modelling was used to classify the contribution of catalytic converter systems to vehicles as an alternative to air pollution reduction, as suggested by the framework. The emissions modelling for this scenario are shown in Table 9.12.

Table 9.12 shows a comparison of the second and third scenarios with a clear indication of the potential amount of reduced emissions resulting from the fitting of catalytic converter systems. The value of CO has been reduced by 92.5%., VOC by 94.64% and NOx by 79.65%. Clearly, the use of this technology would contribute to decreasing the amount of certain pollutants emitted by motor vehicles, and it provides one of possible option for addressing the problem of air pollution caused by motor vehicles.

Table 9.11 Data entered into the COPERT software for the third scenario based on the fitting of catalytic converters to vehicles.

Parameters required	Data entered
Vehicle fleet numbers	Total vehicle fleet = 2,028,698 vehicles (Private vehicles 1,606,479 vehicles), Light-duty vehicles (256,712 vehicles), Heavy-duty vehicles (63,032 vehicles), Public Taxis (102,475 vehicles). All vehicles were considered to have catalytic converter systems fitted.

Table 9.12 Emissions of vehicles in the third scenario based on the fitting of catalytic converter systems compared with the second scenario

Emissions (Mt)	Second Scenario 2020 Increase in the vehicle fleet size	Third scenario 2020 The fitting of Catalytic Converter systems
CO	76,019.64	5,700.61
VOC	6,904.60	369.84
NOx	18,233.74	3,711.30

9.3.1.4. The Fourth scenario 2020 (Decrease in fuel consumption)

The fourth scenario offers an alternative air pollution reduction strategy through reducing the amount of fuel consumed.

The global fuel economy initiative (GFEI) has identified reduced fuel economy improvements worldwide, and also in the long term (IEA, 2012) The required annual change from the GFEI for the period 2005-2030 indicates an annual reduction of -2.7%, and this figure has been used for both petrol and diesel fuel in the fourth scenario for 2010-2020.

The fuel consumption in Tripoli in 2020 was calculated by using the following general formula to calculate the future population given current population and growth rate:

$$Pop_{Future} = Pop_{present} \times (1 + i)$$

Where:

Pop Present = Present Population
i = Growth Rate
n = Period

Therefore $Fuel_{2020} = Fuel_{2010} \times (1+ i)^n$

Where: n = the period (10 years)

i = the growth rate (- 0.027%)

Therefore Fue_{l2020} = 998,752 x $(1+ (- 0.027))^{10}$

= 998,752 x $(0.973)^{10}$

$Fuel_{2020}$ = 759,602Mt

The calculation shows that the total fuel consumption in 2020 will be 759,602 Mt compared to 998,752 Mt in 2010.

In this scenario, the data entered into the COPERT 4 software included the required data and information needed regarding fuel consumption, as calculated in Table 9.13.This includes reducing the amount of fuel consumed by a rate of -2.7% annually. The COPERT 4 Software was used to calculate the emissions by considering the reduction in fuel consumption and assuming that all other parameters remained constant.

Table 9.13 Data entered into the COPERT software for the fourth scenario based on reduced fuel consumption.

Parameters required	Data entered
Fuel consumption types (Mt)	759,602 Mt (Petrol fuel583,982Mt,dieselfuel175,620Mt)

The emission modelling presented in the framework was used to identify the decrease in fuel consumption as an alternative to reducing air pollution from vehicles. Based on the data shown in Table 9.13,the modelling of emissions is shown in Table 9.14. The results show the changes in the status of air pollution as caused by motor vehicles in 2020.

Table 9.14 Vehicle emissions based on a decrease in fuel consumption.

Emissions (Mt)	Baseline scenario 2010	Fourth scenario 2020 Based on the decrease in fuel consumption
CO	41,051.96	31,222.12
VOC	3,728.66	2,835.84
NMVOC	3,337.78	2,538.55
NOx	9,846.55	7,488.81
NO	9,407.23	7,154.68
NO2	439.32	334.13
PM 2.5	363.17	276.21
PM-io	535.84	407.53
PM exhaust	142.35	108.26
co2	3,284,687.43	2,498,172.86
so2	449.85	342.13
Total	3,353,990.14	2,550,881.12

The total emissions that would be caused by motor vehicles considering the decreases in fuel consumption shows a reduction of 23.94.% compared with the baseline scenario emissions.

This scenario provides evidence of another possible solution to address the problem through reduced fuel consumption. If the government, people, and local authorities were to seek to make reductions in the amount of fuel consumed by vehicular engines, this would clearly contribute to reduced air pollution.

9.3.1.5. The Fifth scenario (Decrease in the sulphur content in diesel fuel)

One of the alternative options provided by the framework in terms of fuel technology to help with vehicular emissions was the reduction in the sulphur content of motor fuel. Based on the use of this technology, reductions in the amount of sulphur dioxide emissions emitted by engines would be achieved.

Evidence from the US Environmental Protection Agency (EPA) has indicated successful outcomes in reducing the sulphur content of fuels, and hence reduced the amount of emissions (EPA, 2014). The EPAs Tier 2 and 3 gasoline sulphur programs have indicated achievements in reducing the sulphur content of gasoline by up to 90%.

This fifth scenario has therefore been based on reducing the sulphur content by 90%. The Libyan National Standard for vehicle fuel has identified that the current sulphur content is 150 mg/kg for petrol fuel and 0.08% for diesel fuel. In applying the COPERT 4 software, the data values used with sulphur content were decreased by 90% to 15 mg/kg for petrol fuel and 0.008% for diesel fuel, as shown in Table 9.15.

Table 9.15 Data entered into the COPERT software for the fifth scenario based on the decreased sulphur content of vehicle fuel

Parameters required	Data entered
The sulphur content	The sulphur content mainly affects the calculation of the emissions of S02 The sulphur content was15 mg/kg for petrol fuel and 0.008% for diesel fuel.

Based on input data for sulphur content, the emissions modelling identifies the total emissions for sulphur dioxide, as shown in Table 9.16.

Table 9.16 SO_2 emissions based on the decrease in sulphur content in the fuel consumed

Emissions (Mt)	Second Scenario 2020	Fifth Scenario Based on a reduction in sulphur content
SO_2	833.03	46.78

As shown in table 9.16, the emissions of SO_2 decreased by 94.38% compared with the second scenario. This illustrates another positive measure in addressing air pollution caused by vehicles, and inevitably will influence the health, environmental and economic effects resulting from SO_2 emissions.

9.4. Discussion

There are many techniques for addressing the air emissions caused by motor vehicles, including fuel technology. Many countries and institutions have implemented successful procedures on fuel technology to reduce vehicle emissions. These procedures include reducing the quantities of fuel consumption, eliminating the use of leaded fuel, reducing the amount of sulphur in diesel fuel, and transforming to use of natural gas and hydrogen as well adopting fuel standards.

In the emissions modelling process, several parameters were tested for the different scenarios. The results obtained in the baseline scenario of 2010 presented several kinds of vehicle pollutants in different quantities. A lack of control of the affecting factors would therefore continue to contribute to pollution without some form of mitigating measures.

The second scenario was based on the continuation of all conditions that contributed to air pollution caused by vehicles in the baseline year (2010), without the introduction of improvement measures. The parameter introduced in this scenario included an increase in the number of vehicles to 2020, based on annual increases over the ten year period. The emissions modelling results highlighted a significant increase in the total vehicular emissions in 2020, indicating a marked deterioration and increased air pollution. The increase in the size of the vehicle fleet and its continued growth is a clear indication of the extent of air pollution. Consequently, with the resulting increase in fuel consumption, this factor must be viewed as a priority in any action plan or national strategy to address the problem.

The third scenario was presented as a case of air pollution from cars in the future by assuming that the government and relevant institutions would take action to implement procedures through improving fuel technology. The parameters tested in this scenario showed that reducing fuel consumption will lead to reductions in the amount of vehicular emissions, and would therefore be considered as an influencing factor in addressing air pollution.

The fourth scenario also considered vehicle technology, based on the fitting of catalytic converters to vehicle exhausts. The fifth scenario further considered the reduction in sulphur content as an alternative option to reducing vehicular emissions by reducing the quantities of S02.

Based on the scenarios addressed and described above, it is clear that further deterioration will result in air pollution from cars if the contributing factors continue, without the introduction of controlling measures. The scenarios emphasise that there is a possibility for improving air pollution in future years by introducing improvements to vehicle and fuel technology. The different options must therefore be seriously considered for reducing the air pollution caused by vehicles.

The extent of a deteriorating situation in Tripoli, as well as the possibility of making improvements through mitigation, depends primarily on the actions to be taken regarding the factors affecting air pollution caused by motor vehicles. The continued influence of these factors without making improvements will inevitably lead to deterioration in the health of the population, in addition to having a negative impact on the environment and the economy.

The creation of a national plan ought to involve all of the relevant alternative options to address and alleviate the problem. Some recommendations for improving the air pollution caused by vehicles in the future will be presented in the next section of this chapter.

9.5. The findings from the scenarios

Tripoli has critical concentrations of vehicular emissions. The results from the scenarios show that continuing with the current conditions of air pollution caused by motor vehicles in Tripoli will lead to an increase in pollutants that will heavily impact on health and the environment. From the different scenarios of emissions modelling, it is clear that there is great potential for reducing the amount of pollutants emitted by motor vehicles, and hence their harmful effects.

Table 9.17 shows the results obtained from the modelling for the different scenarios. The most influential scenario for reducing vehicular emissions from the baseline scenario of 2010 was the fourth scenario that involves a decrease in fuel consumption.

The second ranked option was the fifth scenario based on fuel technology and a decrease in the sulphur content of the fuel consumed. The third scenario, also ranked third, involved the fitting of catalytic converter systems.

Based on these different scenarios, it is clear that the possible air pollution situations in Tripoli during 2020 might be better or worse, depending on the actions taken. Policies and plans need to be created and implemented to address the problem and its detrimental effects.

From the results described above, the ranking of the different scenarios, based on their ability to reduce vehicular emissions in 2020, were as follows:

1. The fourth scenario based on a decrease in fuel consumption.
2. The fifth scenario based on a reduction in the sulphur content of fuel.
3. The third scenario based on the fitting of catalytic converters.

Considering the above ranked scenarios, the most desirable alternative to the reduction in the amount of emissions caused by motor vehicles in Tripoli is to move to new fuel technology in terms of efficiencies to reduce the amount of fuel consumed. This approach must therefore be taken into account when developing a national action plan for managing air pollution. A move towards improved fuel technology to reduce consumption represents a major priority in terms of reduced vehicular emissions.

In addition to the options identified through emissions modelling, other recommendations that may be taken and implemented for the management of air pollution can be identified as follows:

- The creation of vehicle emission standards for all kinds of vehicles, particularly new vehicles.
- Theformulation and implementation of air quality laws.
- Thecreation of an air quality monitoring system.
- Theraising of public awareness about air pollution caused by motor vehicles.
- Theimprovement of traffic management, which may include a pricing system to mitigate traffic congestion in specific areas, or places located near to areas that are sensitive to pollution.

Other options available would include road entrance fees and charges according to the distance travelled, based on global positioning technology, where the fees paid depend on the route taken by the cars, in addition to the day and time they travel.

[illegible]

	First Scenario Baseline Scenario 2010	Second Scenario 2020 Increase in the size of the vehicle fleet	Third Scenario 2020 Fitting of catalytic converter systems	Fourth Scenario 2020 Decrease in fuel consumption	Fifth Scenario 2020 Decrease in sulphur content in fuel
OO	41,051.96	76,019.64	5,700.61	31,222.12	41,051.96
VOC	3,728.66	6,904.60	369.84	2,835.84	3,728.66
N VOO	3,337.78	6,180.87	6,180.87	2,538.55	3,337.78
NO_x	9,846.55	18,233.74	3,711.30	[illegible]	9,846.55
NO	9,407.23	17,420.22	17,420.22	7,154.68	9,407.23
NO_2	439.32	813.53	813.53	334.13	439.32
[illegible]	363.17	672.52	672.52	276.21	363.17
[illegible]	535.84	992.27	992.27	407.53	535.84
[illegible]	142.35	263.60	263.60	108.26	142.35
oO_2	3,284,687.43	6,082,553.50	6,082,553.50	2,498,172.86	3,284,687.43
SO_2	449.85	833.03	833.03	342.13	[illegible]
Total	3,353,990.14	6,210,887.52	6,119,511.29	2,550,881.12	3,353,587.07

9.6. Chapter Summary

This chapter has introduced the utilisation of the framework to test various scenarios for the evaluation of air pollution caused by vehicles through changing various parameters affecting the air pollution caused by motor vehicles in Tripoli. The chapter described the parameters affecting the situation and explored different scenarios and their influence on air pollution in the future. The chapter concluded by presenting the findings of the various scenarios that have been assessed. The utilisation of the scenarios within the framework will therefore provide an opportunity for the relevant government departments and other stakeholders to address the identified situations, and further promote the effective management and mitigation of future air pollution caused by motor vehicles in Tripoli.

Chapter Ten

Conclusion and Recommendations

10.1. Introduction

This chapter of the study is dedicated to a discussion of the findings of the research, in addition to its significance, uniqueness, relevance and contribution. At the end of the chapter, some relevant recommendations will be presented for resolving the factors which have led to the air pollution problem caused by vehicles in the study area, as well as recommendations related to other relevant issues; these recommendations and suggestions have been categorized according to the objectives and findings of this research.

10.2. Overview of the thesis

This research aimed to achieve a number of objectives: an investigation of the air pollution problem caused by vehicles in the study area, including the identification of the factors which have contributed to the occurrence of the problem; a review of the relevant national environmental legislation, plans and programmes, and the actions which have been taken to reduce vehicular emissions in the study area; and the gathering of information on the roles of the responsible institutions in terms of addressing the problem. The investigation also included an inventory of air pollutants emitted from cars to identify the actual quantities of vehicular emissions and create a local database on the amounts of these pollutants, which was not previously available. In addition, the research aimed to review the relevant environmental legislation and the level of public awareness on the issues of air pollution caused by vehicles.

In order to achieve the aims of the research and answer the research questions, the research has investigated the problem of air pollution caused by cars in Tripoli and identified the factors which have contributed to the occurrence and increasing severity of the problem, to evaluate the existing status of traffic air pollution in the city of Tripoli.

In order to perform the investigation described above, and to achieve the research aims and objectives, the researcher needed to begin by gaining a deeper knowledge of the topic and obtaining a more comprehensive understanding of all of the measures, aspects and issues related to the topic of the study. The researcher started by reviewing many previous studies, which concentrated on issues related to the objectives of the research. This involved identifying the factors which have contributed most to the problem and the health, environmental and economic effects resulting from exposure to traffic air pollution, as well as reviewing the latest developments regarding ways of addressing the problem.

The next stage was collecting the required information on all aspects related to the topic, which was done according to what had been learnt from the review of previous studies. For this purpose, several specific questions were developed to be posed to the participants in the study. The research questions focused on the occurrence of the problem and the factors that have contributed to it; the relevant national environmental legislation; the role of institutions in addressing the problem, the difficulties facing the responsible institutions in terms of their actions, and the actions taken in the past to alleviate the problem; the options available to the government for plans and future projects to address this problem, the possibility of creating a management strategy to address the problem, and the economic, technical, legislative and institutional instruments needed for the implementation of such a strategy.

For the purpose of achieving the aims and objectives of this study, the mixed-method approach (qualitative and quantitative) was selected in this research because it enabled the researcher to exploit the advantages and strengths of each approach. Three methods were employed for collecting the primary data: personal in-depth, unstructured interviews with ten people from three different institutions related to the research topic; questionnaires, for which the sample was selected by using the random sample selection system; and direct observations, through undertaking field visits to the study area. The secondary data needed for the study were collected from previous studies related to the subject of the research, scientific reports and annual publications by local institutions interested in the topic, as well as archive libraries, newspapers and the Internet. Some other important data were not obtained by the data collection methods mentioned above, as they were unavailable; this information was provided by the researcher, in the inventory of the amount of pollutants emitted from cars for the period 2005-2010.

The methods employed for the data analysis included qualitative and quantitative analysis methods as well as statistical analysis, in addition to the application of a proposed theoretical framework for air pollution from vehicles in the study area. The questionnaire data were analysed using the Statistical Package for Social Sciences (SPSS), the statistical software package that is most widely used for quantitative analyses by the social sciences, while the interview data were transferred into a Microsoft excel program for sorting and grouping for the purpose of analysis.

In Chapter eight of this study, all issues related to the topic of air pollution from cars in the study area were discussed through a presentation of the evidence obtained from the questionnaires, interviews, direct observations and previous studies, in order to describe the status of the problem of air pollution caused by vehicles; this evidence provided a detailed account of the size of the problem and the factors which contributed most to it, as well as all other relevant measures related to air pollution from vehicles in the study area.

A framework has been developed for the purpose of evaluating the status of air pollution caused by motor vehicles and applies it to test various scenarios with changes in the parameters affecting air pollution through testing the data to highlight the variations and the aspects influenced, which have a major impact.

10.3. Achieving the aims and objectives of the research

The research findings confirmed and provided evidence regarding the extent to which air pollution caused by vehicles has occurred in the city of Tripoli in the past few years, where this research discussed and reviewed all aspects related to the subject and pinpointed the contributing factors and growth of the phenomenon of air pollution from cars.

This study provided an inventory of pollutants emitted from motor vehicles over a five year period, which proved that the amount of pollutants emitted has continuously increased over the past few years. This research showed that a deficit is clear in the legislative aspects related to the subject of study and also that there exist a lack of human capabilities, equipment, and programs as well a national strategy to address the problem. The study, conducted with responsible and expert people and based on the collection and analysis of the evidence, has indicated that no procedures or actions have been taken to solve the problem in the past for many reasons, and that the government and local authorities have faced obstacles in terms of addressing the problem.

This study has evaluated the status of the air pollution problem caused by vehicles in Tripoli in the past few years and has applied a framework for testing various scenarios for air pollution caused by vehicles in the coming years. This showed the possibility of mitigating the problem as well as the possibility of the air becoming more polluted, where that depends on the hypotheses of each scenario.

10.4. Findings of the research

This study presented the facts and scientific evidence using reliable data on the status of air pollution caused by motor vehicles in Tripoli, as well as analyzing the affecting factors that have, directly or indirectly, contributed to the presence of this serious environmental problem. The study employed various scenarios to estimate the different expected situations related to air pollution caused by vehicles in the future, which were tested through the use of the proposed framework.

The evidence and facts were presented by the study on this topic and related aspects can be represented by the following points:

1. Air pollution problems caused by motor vehicles in Tripoli were not studied in previous years.

2. Tripoli has suffered from an air pollution problem due to the increase in the size of the vehicle fleet and a lack of public transport infrastructure as well as the continuing reliance on the use of petrol fuel in vehicle engines.

3. The inventory of vehicular emissions for the period 2005-2010 indicated that there has been an extreme increase in vehicular emissions over the past years.

4. The main affecting factors that have contributed to the problem were economic growth, fuel consumption, the lack of a public transport infrastructure, and the weakness of the relevant environmental legislation.

5. Individuals' reliance on their own vehicles for transportation in the city is high due to many reasons, including the absence of proper public transport, lower prices of imported vehicles and the low tax on imported vehicles, which have dramatically helped to encourage people to own private cars and increase their reliance on their own vehicles for travel in the city.

6. Although Libya produces compressed liquid gas, there were no plans to transfer to clean fuel such as compressed liquid gas in vehicle engines. In

addition, the government has not imposed a tax on the use of petrol and diesel fuel, which are available at a low price.

7. The absence of air quality laws and environmental laws lack many of the technical measures on air quality which need to be included.

8. The culture of car ownership is widespread, particularly among young people; people have contributed to the problem by importing large numbers of vehicles which are old and in poor condition. No social activities have been undertaken to contribute towards raising public awareness of the problem and encouraging the citizens to make a positive contribution in terms of addressing the problem.

9. The lack of health surveys on diseases and their relationship to air pollution from cars. Environmental effects were observed on buildings and plants in previous studies, but no research studies have been conducted to evaluate such environmental effects. The assessment of economic effects was unavailable.

10. The concerned institutions lack the human capacity as well as the required equipment and devices to conduct measurements of air pollutants and monitor air quality. Also, there is a lack of national consultants and experts on this topic.

11. Strategy and action plans to address the problem were available in the past. Also, there were no environmental surveys or research studies, as this topic was not considered a priority.

12. Various scenarios were suggested based on the changes in the current status of the problem, which showed possible ways to improve the situation,

which requires the creation of strategies to address the problem. These strategies should be short, medium and long term and comprehensive, involving all of the related issues.

10.5. Limitations of the research

This research deals only with a specific issue, the problem of air pollution resulting from cars in the city of Tripoli, and a certain period(2005-2010), because of the limited information for the period before the year 2005, which was not properly documented and cannot be trusted for use in this research. The research did not aim to study the sources of air pollution in the city other than the emissions from vehicles; also, the research does not address every kind of pollution that could have originated from vehicles, including noise, waste from used oil, waste from scrap and accidents, but focuses only on air pollution emitted from motor vehicles. Moreover, the research does not engage in making comparisons between air pollution from cars and air pollution from other sources in the city.

This research encountered a series of technical and administrative difficulties due to the inability of the researcher to obtain with ease some of the required data available in the concerned institutions: this necessitated more time, effort and repeat visits and re-coordination with the concerned authorities. These difficulties included the lack of data about a number of the main issues related to the topic of the study, including the lack of previous local studies related to the research topic both in the study area and at the national level. There was no database available on the amount of pollutants emitted by cars and no measurements of the concentrations of vehicular emissions in the city. There also existed no data on the quantity and concentrations of air pollutants emitted by other sources which could have been used for comparison to determine the size of the contribution of air pollution in the city from traffic, and no health or environmental surveys on the actual extent of the damage to health, the environment and the economy as a result of exposure to air pollution from cars in the city. The difficulties included the limited duration of the research period, the specification of the field of study, and the cost of travel from Britain (where the researcher is based) to Tripoli, the location of the study, which precluded more than one fieldwork trip.

10.6. Uniqueness of the research

The choice of air pollution caused by motor vehicles as a topic for this study has given it a priority in the investigation of this environmental phenomenon, which might make this study unique at the national level.

This study is unique because it was the leader in conducting an inventory of pollutants emitted from cars during the period 2005-2010; these data were not previously available and thus a local database was made of the amount of pollutants emitted by cars for several consecutive years that was not previously available.

This research is unique because it provided field measurements of the concentrations of pollutants from cars in the city centre as well as compared these measurements to the concentrations of emissions in the city of Sheffield (UK), which comparison has never been undertaken in the past.

This study is unique as it is the first time a framework has been developed to evaluate the air pollution caused by vehicles, which was impossible previously. This framework could also be applied to other cities, where the circumstances are similar to those of the study area.

This study can be regarded as unique because it presented and tested various scenarios regarding the predicted situation regarding air pollution in the future, based on several hypotheses which were suggested in this study.

Lastly, this research is unique as it presents an important issue and thus opens up the prospect of new knowledge and advanced support for further research and investigation on all aspects of the economic, social and environmental risks related to air pollution by vehicles.

10.7. Relevance of the research.

The topic of the research which is addressed by this research includes many measurements and aspects that are linked, directly or indirectly, with the contents of the research; there are many institutions and local bodies responsible for the environment, transport and planning sectors which assume the functions and responsibilities linked to one aspect of the research, particularly the General Authority for the Environment, which is the higher authority responsible for monitoring air quality and protecting it from various sources of pollution, including air pollution from road transport.

The results of this research are closely associated with what the Environment General Authority needs in order to perform its tasks, in that the research has provided a large amount of information on the extent of the problem and the factors that have contributed towards it. The EGA authority lacked this information for a number of reasons, as reviewed during this research; thus, this research provides a tool for monitoring air quality and protecting it from vehicular pollutants.

Some regional and international organizations concerned with the control of air quality and the protection of the atmosphere lacked data and information about the air quality in Libya; this research has provided extensive data and findings about the air quality in the study area, which could be indicative of the level of air quality at the national level, and this research is therefore linked to the work of some regional and international organizations including WHO and UNEP as well as the Mediterranean Action Plan (MAP).

10.8. Research contribution

The air pollution problem has social, economic, political, and cultural aspects; this problem has many dimensions: health, environmental, and economic. The air pollution problem resulting from motor vehicles has already been investigated by researchers in many countries, where the previous studies have confirmed the importance of this problem. The air pollution problem was considered as a most dangerous environmental problem in the cities due to its health, environment and economic effects. The previous studies have provided several options for addressing this problem. Several concerned studies on the topic of air pollution caused by motor vehicles have addressed the problem from different angles; technical, legal, economic, health and environmental, and have proposed many solutions to it. Unfortunately, there was a gap in this issue, as the previous studies failed to provide a framework for assessing the status of air pollution from cars. They had also failed to provide and test different scenarios to analyze what to expect from the status of air pollution from cars in the future, where these studies failed to develop a specific framework suitable for evaluating and presenting various scenarios to test the different parameters. These could play an important role in changing the situation regarding air pollution from cars in the future, and is a necessary issue which the previous studies have missed. It has not been solved in the past; therefore, it was necessary to fill this gap in knowledge related to the topic of air pollution caused by motor vehicles.

For this purpose, there was a need to fill this knowledge gap and that was the contribution of this research in solving this problem and filling the gaps in the previous studies, where this study has provided and developed a framework for evaluating the status of air pollution resulting from motor vehicles. This developed framework has contributed to the knowledge of this topic as it has provided deep information, data and more knowledge on the factors that have contributed to the phenomenon of air pollution caused by vehicles and presented them in a logical sequence. It started by describing how the problem occurred and ended by presenting the options available to address the problem, followed by testing various scenarios on the status of air pollution caused by vehicles in the future.

This research, by developing a specific framework on air pollution caused by motor vehicles has contributed towards providing new knowledge of the assessment of the status of air pollution resulting from vehicles. It also suggested and tested various scenarios for the status of air pollution resulting from motor vehicles in the future, whereby the framework presented and tested different scenarios through changing the parameters affecting pollution and then describing the different states of air pollution caused by vehicles in the future based on the suggestions and tests of the various scenarios.

Accordingly, this research has contributed to the development of scientific knowledge on the topic of air pollution from cars by developing a framework for the scientific assessment of the problem of air pollution from cars and providing a more comprehensive assessment and more accurate description of the situation regarding air pollution from cars. In addition, this framework has contributed by facilitating the development of perceptions of the various scenarios for the status of traffic air pollution for the future. Therefore, this research has greatly contributed towards filling of the gaps in knowledge that were missed in the related previous studies.

10.9. Recommendations

The research has concluded from the results obtained in this study that there were many factors in the study area which have affected the occurrence and increasing severity of the problem. The research has reviewed the weaknesses and deficiencies related to some necessary aspects related to the subject of the study, which need to be addressed in order to resolve the problem. For this reason, the researcher believes that there is an urgent need to present a number of recommendations and to take necessary the actions to implement them properly in order to address the problem of air pollution caused by vehicles in the study area. The proposed recommendations have been categorized into several groups covering all the aspects of the study and can give great assistance with addressing the problem. The research recommendations are as follows:

10.9.1. Recommendations on the development of a national environmental law

The recommendations relate to the relevant national environmental legislation and include the following:

i. The issuing a national air quality law which should include all aspects related to the issue of air pollution from cars and cover all of the shortcomings that have been ignored in the current environmental protection law (Act 15/2003) regarding air pollution issues.

ii. Develop and amend the environmental protection law (15/2003) to address the weaknesses in the act, with a focus on the need to include standards for air quality and vehicular emissions.

iii. Develop the traffic law to take into account the environmental aspects associated with the use of vehicles, including on-going maintenance for automotive engines and periodic disclosure.

iv. Create a specific court to consider the issues relating to cases of pollution resulting from practices contrary to the law, including air pollution resulting from the lack of compliance with environmental laws for the control of air pollution from various sources, including land transport on the roads.

10.9.2. Recommendations for supporting the responsible institutions

i. Raise the structure of EGA to be an independent ministry so that it can require all parties, at both the individual and institutional levels, to comply with all of the guidelines and instructions issued by the authority in terms of protecting air quality, including addressing air pollution caused by vehicles.

ii. Develop the capability of the technical staff of EGA and provide the required equipment to measure and analyse pollutants emitted from cars.

iii. Raise environmental public awareness on issues related to air pollution from cars, through the provision of the media of awareness and rehabilitation of specialists and increased activities related to this important issue.

iv. Establish an air quality monitoring system in the city to ensure the continuous monitoring of the sources of air pollution there and provide data assessment of the status of air quality in the city.

10.9.3. Recommendations on reducing the increase in the size of the vehicle fleet

i. Control the importation of private cars through raising the tax on imported vehicles and restricting the importation of old models, as well as issuing technical requirements for importing such cars.

ii. Encourage people to reduce their reliance on private vehicles for transport in the city by improving the public transportation sector to offer satisfactory services for travellers and encouraging them to reduce their use of private cars.

iii. Provide specific transportation for employees and students in different institutions and schools, which will reduce the use of private vehicles to travel to and from work and school; this will lead to a decrease in the size of the private vehicle fleet.

10.9.4. Recommendations for improving the public transport sector

i. Develop the infrastructure of the public transport sector in the city and improve the level of services offered by this sector to encourage travellers to use public transport as well as encourage investments in public transport by providing the necessary administrative and financial facilities.

iii. Speed up the implementation of the proposed city train project, which will play a central and important role in improving the services of the public transport sector and also reduce the severity of traffic congestion.

iv. Provide free buses to take people shopping in the city centre, to encourage them to forego the use of their own vehicles in the shopping centres, which creates severe traffic congestion.

v. Establish means of public transport which depend on clean fuels, such as electric trams and trains.

10.9.5. Recommendations on raising public awareness of air pollution caused by vehicles

i. Support and promote environmental public awareness programmes on air pollution from cars; provide the necessary equipment, including posters, leaflets and documentation, in additional provide seminars, scientific conferences and workshops related to air pollution caused by vehicles.

ii. Develop the environmental library and make it available for all people as an effective tool to raise public awareness among citizens; set timetables for areas to be visited and tell people about these appointments in order to give more people more opportunities to raise their awareness on issues of air pollution from cars.

iii. EGA and local radio and television stations in the city need to co-operate in order to provide regular programmes to make people aware of the issue of air pollution from cars; specialists and decision-makers will be needed to participate in such programmes.

iv. Regional and global environmental studies and environmental researches need to be translated into Arabic for use in increasing people's knowledge and awareness of environmental issues and in following the latest developments in the field of air pollution from cars.

10.9.6. Recommendations on the development of fuel technology

i. Reconsider the pricing of petrol and diesel fuel and impose a carbon tax on fuel in order to reduce the amount of fuel consumed in vehicle engines.

ii. Create a gradual timetable for phasing out the use of petrol and diesel fuel in car engines, while studying alternative options for using less polluted fuel, including the use of compressed liquid gas fuel for private cars at the national level, through providing the necessary infrastructure for it.

10.9.7. Recommendations for the management of traffic congestion

i. Provide advanced equipment to control and monitor traffic congestion on the road network to facilitate the flow of traffic, as well as reconsider the layout of the road network in the city.

ii. Levy taxes on the road network and car parks in the city centre to restrict access by private cars to congested areas, to reduce the severity of traffic congestion, particularly in shopping areas.

iii. Develop the car parks in the city to ensure that they accommodate the largest possible number of cars, which will contribute to the reduction of roadside parking.

10.9.8. Recommendations for a management strategy and its instruments to reduce air pollution caused by motor vehicles in Tripoli

i. Conduct a comprehensive assessment of the status of air quality in the city, including air pollution from cars, as a necessary preliminary stage for creating the required strategy on air pollution caused by vehicles.

ii. Establish an integrated strategy in the short, medium and long term involving all of the relevant sectors, including the environment and transport sector, traffic police, planning, energy, and the economy.

iii. The strategy must identify the legislative, institutional and financial mechanisms needed to implement the strategy and should clearly define its objectives and the mechanisms and requirements for its implementation.

vi. The non-governmental institutions must be included among the institutions involved in the implementation of the proposed strategy.

10.10. Suggestions for further research

The topic of this research has received no attention from the concerned institutions, including the EGA as the authority responsible for this issue; also, specialists in the various research centres have not conducted research studies or environmental surveys on the subject of air pollution from cars either in the study area or at the national level, as confirmed by the evidence presented by this study.

This research has investigated the problem of air pollution from cars and the factors which affect it, and has addressed certain elements related to the topic of the study, including the legal aspects, and health, environmental and social issues; each of these elements plays a role in this problem and needs more in-depth study; therefore, this research has opened new windows for national researchers and experts to conduct many research studies to investigate the various aspects of the topic and thus fill the gaps in the scientific research in the country on this subject, by providing large amounts of data and obtaining multiple results. Many research studies on the environmental, economic and social aspects of the topic need to be considered by professional researchers, with the support of scientists and the concerned institutions, agencies and departments, involving planning, transportation, environment and other related factors to provide the financial and necessary technical support to undertake these studies.

This research has identified several topics, which could be considered as subjects for research studies by those interested in research at the national level, in terms of the environmental legislation, economic aspects, health and environmental effects of air pollution, and other forms of pollution from land transport, in order to encourage further study and research in this area and its importance for the integration of the subject from all its aspects.

The main subjects for further research which were suggested include the following:

i. Evaluation of the health effects resulting from the exposure to air pollutants from motor vehicles.

ii. Assessment of the economic impact resulting from the negative effects of air pollution.

iii. Investigation of environmental impacts resulting from air pollution emitted from various other sources.

iv. Employment of remote sensing technology to monitor the air quality both in the study area and nationwide.

v. Investigation of the activities of industry, agriculture, waste disposal and power generation and their impact on air quality in the city.

vi. Creation of an inventory of air pollutants emitted from different sources in the city.

10.11. Chapter Summary

This chapter presented the conclusion and recommendations; it summarized the findings of the research and highlighted its significance, uniqueness, relevance and contributions. Recommendations were presented for addressing the air pollution problem caused by vehicles in the study area. These recommendations were categorized according to the objectives and findings of this research, which have provided extensive information about the air pollution caused by vehicles in the city of Tripoli and other relevant issues.

This research has encountered a series of technical and administrative difficulties due to the inability of the researcher to obtain with ease some of the required data available in the concerned institutions. These were acknowledged and it was shown how they affected the study. Such difficulties included the lack of some of the data about a number of the main issues related to the topic of the study.

This chapter has presented the factors that made this study unique and distinctive, including the fact that it is the first to deal with an environmental issue- the health and social needs of the citizens in the study area and country.

The research has contributed through providing more knowledge and understanding about the air pollution problem caused by vehicles, examining the relationship between this problem and factors, and applying a theoretical framework as well.

The chapter ended by highlighting that the research has opened up new windows for national researchers and experts to conduct many research studies to investigate various aspects of the topic.

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Appendices

Appendix 1

The Questionnaire

Dear Participator

This questionnaire was prepared for the purpose of collecting information and data about air pollution caused by motor vehicles and relevant issues in the city of Tripoli. This questionnaire is a part of a PhD dissertation.

The author seeks your opinions and views on this problem. Your participation in this questionnaire will be greatly appreciated and will help in the evaluation of the problem, enabling us to successfully address the problem.

General Information

1- Your Gender

Male ☐	Female ☐

2- Your Age

Less than 20 ☐	20 - 39 ☐	40 - 50 ☐	Older than 50 ☐

3- Your Education level

Fundamental	Secondary	University	After University
☐	☐	☐	☐

Section One: Air Quality in Tripoli.

Q.1. *How would you describe air quality in Tripoli?*

Excellent	
Good	
Acceptable	
Poor	
Very Poor	

Q.2. *What do you consider to be cause of air pollution in Tripoli?*

Industry	
Agriculture	
Motor Vehicles	
Waste Disposal	
Heating / Cooling Systems	
Power Generation	
Natural Sources	
Toxic materials	

Note: For the coming parts of the questionnaire I would request you to choose one answer from the given answers, the keys of answers as shown below:

Answer	Completely Agree	Agree	Neutral	Disagree	Completely disagree
Key	5	4	3	2	1

Section Two: Air pollution caused by motor vehicles in Tripoli.

Q.3. *To what extent do you agree or disagree with the statement says that the Motor Vehicles contribute to air pollutants in Tripoli?*

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1).

No	Statements	1	2	3	4	5
1-	*The Motor Vehicles contribute to air pollutants in Tripoli?*					
2-	*The Motor Vehicles cause air pollution in Tripoli?*					

Section Four: the factors affecting air pollution caused by motor Vehicles in Tripoli.

Q.4. *To what extent do you agree or disagree with the statements about the major affecting factors have contributed to increase air pollution caused by motor vehicles in Tripoli?*

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1).

NO	Statements	1	2	3	4	5
1-	The increase of the population growth in the city is one of the affecting factors that led to the air pollution from motor vehicles					
3-	The economic growth has contributed in increasing of air pollution caused by motor vehicles in Tripoli?					
4-	The Increase of the vehicle fleet has contributed to the air pollution caused by motor vehicles in Tripoli.					
5-	Quality and quantity of fuel consumption have contributed in increasing of the traffic air pollution.					
6-	The weakness of national environmental law has contributed in increasing of air pollution caused by vehicles in Tripoli.					
7-	The lack of public awareness has contributed in growing of air pollution from motor vehicles.					
8-	The lack of public transport sector has contributed in increasing of air pollution caused by motor vehicles.					
9-	The severity of traffic congestion has contributed in increasing of air pollution caused by motor vehicles in Tripoli					
10-	The weather conditions have played a significant role in increasing of air pollution caused by motor vehicles in Tripoli.					

Section Five: Effects of air pollution caused by motor vehicles in Tripoli.

Q.5. *To what extent do you agree or disagree with the statement says that there are effects of air pollution caused by motor vehicles in Tripoli?*

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1).

No	Statements	1	2	3	4	5
1-	*There are effects of air pollution caused by motor vehicles in Tripoli.*					
2-	The Pollutants emitted from vehicles have effects on public health.					
3-	The air pollution caused vehicles in Tripoli has environmental effects?					
4-	There is an increase in average temperatures due to increased air pollution caused by vehicles in Tripoli					
5-	There are economic effects as a result of air pollution caused by vehicles in Tripoli?					

Section Six: The actions taken and relevant policies to manage the air Pollution caused by vehicles in the city of Tripoli

Q.6. *To what extent do you agree or disagree with the statement says that responsible authorities have implemented their tasks in the field of addressing air pollution caused by motor vehicles?*

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1).

No	Statements	1	2	3	4	5
1-	The environment general authority has implemented its tasks in the field of addressing air pollution caused by motor vehicles?					
2-	*The Institute of Traffic Police has taken effective actions in terms of traffic management in the city.*					
3-	*the local responsible institutions face obstacles and difficulty in their roles in terms of addressing air pollution caused by vehicles?*					
4-	The local environment law needs amendment and development in terms of air pollution caused by motor vehicles in Tripoli					
5-	Actions taken in the past to address the problem of air pollution from cars in the study area has reduced air pollution caused by vehicles in Tripoli					
6-	The responsible authorities have plans and programmes in terms of reduction of air pollution cause by vehicles in the city					

Section Seven: Achievement of reliance on private vehicle to travel

Q.7.*Do you own a vehicle?* Yes ☐ No ☐

Q.8.*what do you use the vehicle for?*

Move to work	
Children to school	
Visiting family and friends	
Leisure activities	
Business	
Other	

Q.9. *If vehicle ownership is important to you, why?*

Utility	
Liberty	
No public transport	
Other	
Not important	

Q.10. *Do you use the public transport?*

Often	
Sometimes	
Never	

Q.11. to what extent do you agree or disagree with the following statements concerning the achievement of reliance on private vehicle to travel.

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1)

No	Statements	1	2	3	4	5
1-	*people should decrease reliance on private vehicles to travel*					
2-	The reliance on private vehicles can be achieved by Strict control on the import of old cars and dilapidated?					
3-	The decrease of reliance on private vehicles to Travel can be achieved by Support and encourage public transport sector					
4-	The decrease of reliance on private vehicles to Travel could be achieved by increase the price of consuming fuel.					
5 -	Decrease of reliance on private vehicles to travel could be achieved by Increase cost on customs tax for imported cars					

Section Eight: Available options for the reduction of air Pollution caused by the motor vehicles in Tripoli?

Q.12.*To what extent do you agree or disagree with the following available options for addressing air pollution caused by motor vehicles in Tripoli?*

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1).

No	Statements	1	2	3	4	5
1-	The improvement of vehicle technology is considered as available options for addressing air pollution caused by motor vehicles in Tripoli?					
2-	The development of fuel technology could have significantly contribution for reducing the amount of pollutants emitted from vehicles.					
3-	Develop of national environmental laws could play a role to accelerate the reduce the air pollution caused by motor vehicles.					
4-	Supporting of responsible authorities is an option in addressing of air pollution caused by motor vehicle in Tripoli.					
5-	Development of the public transport sector has a significant contribution to addressing the problem of air pollution from vehicles.					
6-	Raise of public awareness has a greater role in addressing the problem of air pollution from vehicles.					
7-	Improve the management of traffic congestion is an available option to reduce the air pollution caused by vehicles in Tripoli					

Section Nine: Management strategy to reduce air pollution caused Motor vehicles in Tripoli

Q.13. To what extent do you agree or disagree with the statement that the current status of air pollution from motor vehicles in the city needs development of an environmental strategy to address the problem and develop effective solutions?

Reminder: Completely Agree (5), Agree (4), Neutral (3), Disagree (2), completely disagree (1).

No	Statements	1	2	3	4	5
1-	The current status of air pollution from motor vehicles in the city needs development of an environmental strategy to address the problem and develop effective solutions					
2-	*The strategy needs to provide technical, institutional, economic and social instruments*					

Thank you for your agreement to fill out the questionnaire

I appreciate your cooperation

Appendix 2

The Personal Interview Questions

1. Research question one: Air quality statues in Tripoli city

- How do you describe the status of air quality in Tripoli and what are the main sources that may cause air pollution phenomena in the city?

- Do you consider that the air quality in Tripoli the required criteria?

- What are the main sources of the air pollution in Tripoli?

2. Research question two: contribution of motor vehicles to air pollution

- How does the use of motor vehicles contribute to air pollution?

3. Research question three: Air pollution caused by motor vehicles in Tripoli

- To what extent does traffic air pollution occur in Tripoli and what are that factors have led to this environmental problem?

- Do you consider that vehicles cause air pollution problems in the city?

- What are the affecting factors that have led to air pollution caused by vehicles in Tripoli?

4. Research question four: Effects of air pollution caused by motor vehicles in Tripoli.

- How is air pollution caused by motor vehicles relevant to health, environment and economic Matters?

- Do you think that there are health impacts as a result of exposure to air pollution emitted from vehicles in Tripoli?

- Do you think that there are environmental impacts as a result of exposure to air pollution emitted from vehicles in Tripoli?

- Are there economic impacts resulting from air pollution caused by vehicles in Tripoli?

5. Research questions Five: The actions taken and relevant policies to address the air pollution caused by vehicles in Tripoli.

- What actions have been taken to reduce traffic air pollution? Are there any policies, plans, legislation and programmes relevant to address of air pollution caused by vehicles in Tripoli?

- What are the roles of EGA in terms of reducing air pollution caused by vehicles? Do you think that EGA has the required technical capability to address the issue of air pollution caused by vehicles? If the answer is no, what are the obstacles?

- Do you have the potential technical, human and financial resources for the control and management of traffic air pollution and resolve the problem?

- Does the Environment General Authority conduct regular measurement of air pollutants emitted by vehicles? If the answer is yes, what are the measured pollutants? If the answer is no, what are the obstacles?

- What are the main difficulties and obstacles that have faced EGA in terms of addressing air pollution problem caused by vehicles?

- What are the roles of the GTL in addressing the problem of traffic air pollution in the city?

- Does GTL have capabilities for implementation of its tasks in terms of addressing traffic air pollution problem in the city? If not, what are the difficulties faced in this regard?

- Are vehicles subject to technical inspection to detect the efficiency of engine performance? If the answer is no, will you achieve this in the future?

- Is there a traffic management system to facilitate traffic congestion on the road network in Tripoli? If not, will you have it in the future?

- What are the main difficulties and obstacles that have faced GTL in terms of contribution in addressing air pollution problem caused by vehicles?

- Does environmental legislation have the ability to control and protect the air quality from road transport pollution?

- Do the environmental legislation and traffic law deal with technical investigation of efficiency of vehicle engines?

- Is the Traffic Act able to manage the traffic congestion and control for vehicles that may emit air pollution in the city?

- Have there any actions have been taken in the past to reduce the problem of air pollution from cars in the study area? If the answer is yes, what are these procedures?

- Do you have plans and programmes for reducing traffic air pollution in the city? If the answer is yes, what are the main elements involved? If the answer is no, do you have future projects of interest in this subject?

6. Research questions Six: Decreasing the reliance on private transport in the city.

- Why should people decrease reliance on private vehicles to travel? And

How can that be achieved?

- Why should people be reducing reliance on private vehicles?

- How would the growth of private transport be achieved?

- What is the size of contribution of public transport in the city's total fleet of vehicles? What are its components?

- Do people rely on public transport for travel in the city?

7. Research question seven: Available options for reduction of air pollution caused by motor vehicles

- What are the main actions that should be taken to reduce air pollution caused? by motor vehicles in Tripoli city7

8. Research question Eight: Management strategy and instruments required to reduce air pollution caused by vehicles in Tripoli.

- What are the instruments required (technical, institutional, economic, social, plans and policies etc.) To develop management strategies of traffic air pollution?

- Do you think that there is an urgent need for a strategy for management of air pollution caused by motor vehicles in Tripoli? If yes, do you have a proposal or conception of what should be included in this strategy?

- What are the instruments required (technical, institutional, economic, social, plans and policies etc.) To develop management strategies of air pollution caused by from motor vehicles?