Comparative analysis of vehicular emission levels by fuel type and Vehicles compliance to standards in Islamabad and Muzaffarabad.

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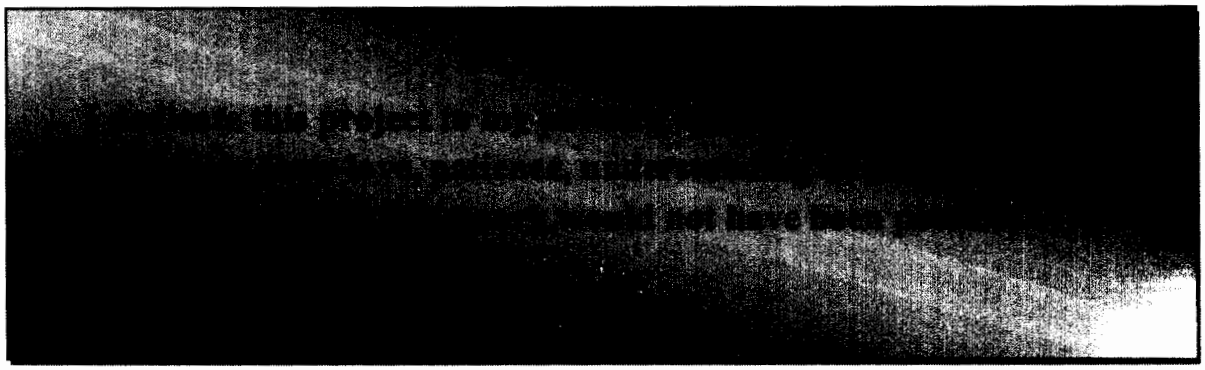

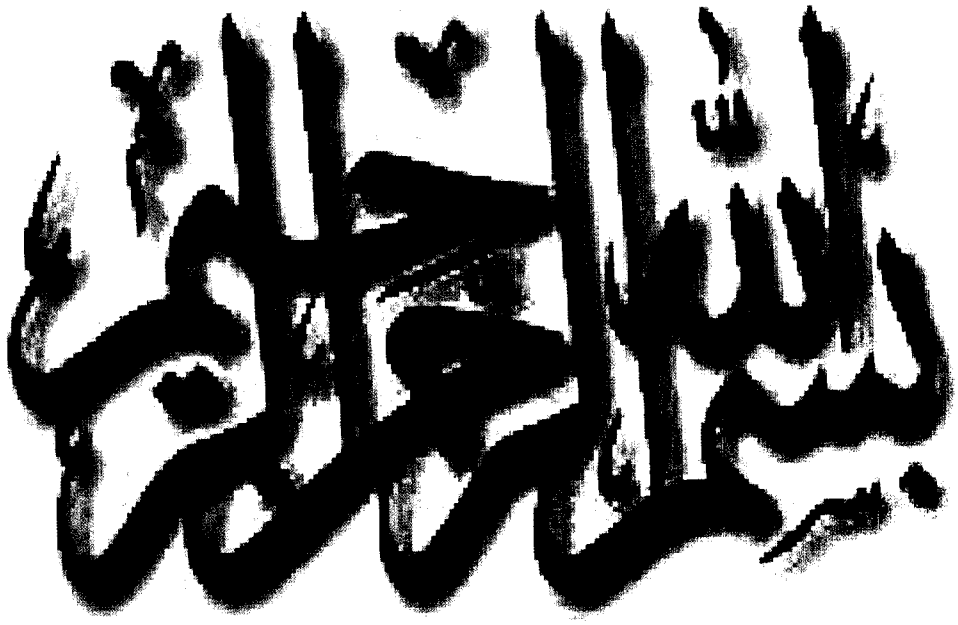

Comparative analysis of vehicular emission levels by fuel type and Vehicles compliance to standards in Islamabad and Muzaffarabad

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A thesis submitted to international Islamic University Islamabad in partial fulfillment of the requirement of degree of Master of Science in subject of Environmental Science

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ABSTRACT

Transport is an essential facility for individuals and societies. People interact, and get access to production units because of mobility ensured by the transport. Rapid urbanization and industrialization have caused tremendous increase in transportation; which has resulted in immeasurable damage to environment. The increased dependence on transport also resulted in increased exposure to noise and air pollution. Some segments of societies are more prone to hazardous impact of air pollution, such as people living in semi-urb and sub-urb areas near motorways with heavy traffic. Increased trend of private motorized transport system has worsened the situation. In Pakistan, the rapid increase in vehicle number has caused damage to air quality. In this dissertation two cities of Pakistan, Islamabad and Muzaffarabad, are focused. Vehicular emission testing project was undertaken by EPA in both cities in 2009-2010. First part of dissertation discusses type of fuel used most frequently in the both cities. It would give the energy consumption ratio of each fuel, proportion being consumed and Comparative analysis of vehicles compliance to standards. It would further help in assessing the situation of environmental regulations implementation in Islamabad and Muzaffarabad. Further, it discusses the level of vehicular emissions from petrol, diesel and CNG vehicles. In order to check the compliance of diesel vehicles, opacity was considered to be standard parameter, while for petrol vehicles, CO and HC level was recorded. Type of vehicles most frequently used in Muzaffarabad have also been discussed. Finally, efficient and effective solutions were furnished for the solution of transport problem in Pakistan.

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List of Abbreviations

1.	CNG	Compressed natural gas
2.	CO	Carbon monoxide
3.	ENERCON	National Energy Conservation Centre
4.	EPA	Environmental protection Agency
5.	FORS	Federal Office of Road Safety Australia
6.	g	Gallon
7.	GCF	Gross capital formation
8.	GDP	Gross domestic product
9.	HC	Hydrocarbon
10.	LPG	Liqified petroleum gas
11.	M2W	Motorized two wheeled vehicles
12.	M3W	Motorized three wheeled vehicles
13.	Mj	Mega joules
14.	MoE	Ministry of Environment
15.	No_x	Oxides of Nitrogen
16.	ppm	Parts per million
17.	VOCs	Volatile organic compounds
18.	WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.0 Introduction

Air is utmost source of survival for living beings on earth. This precious resource is being degraded at a rapid pace. Over past few years, it is of high concern mainly due to its after effects now being observed even by lay men. Main reasons for its degradation are the continuous and rapid growth in population, urbanization, industrialization and transportation (Ilyas, 2007). Air pollution has multiple effects on economy, health and social conditions. Major contributor of air pollution is vehicular emissions. Addressing transport air pollution is challenging enough because it involves a variety of pollutants from a range of motor vehicles and other sources, the daily travel and vehicle purchasing, operation, and maintenance choices of millions of vehicle users, and a multitude of actors and affected groups (Ilyas, 2007). This challenge becomes worse in case of Pakistan, because of the restricted financial, technological, and administrative resources.

Over the past years, environmental quality has been regularly checked through various legislations and their implementation and thereby ensures improved citizen health (Pak EPA). Besides these efforts, there is high risk of public exposure to harmful and toxic chemicals particularly from air pollution. Some segment of population is more prone to harmful effects of air pollution. These people mostly live in semi-urb or sub-urb areas, and are socio-economically low including large number of ethnic groups minorities. These differences among race/ethnicity income group and level of exposure to health risk have resulted in environmental inequality (Sohail, 2005). Provision of cleaner

environment is based on advanced research and interventions of scientific data specific to level of risk. Research in this domain has been relatively limited. Malfunctioning of lungs is common in children who inhale more polluted air. This has resulted in acute respiratory diseases in children as they enter in adulthood. Increased chances of asthma have also been seen in children with high level of exposure to air pollution (Shima and Adachi, 1998). Toxic pollutants emitted from local regional and national vehicles are set by source category that is point or non point source.

Establishing and implementing health based air quality emission standards would help in assessing quality of air and health conditions of citizens in certain areas (Charnley and Goldstein, 1998). In order to check the level and quality of vehicular emissions in a city, the factors including number of cars and fuel type must be considered.

Like many Asian countries, Pakistan also pays the price of rapid industrialization, urbanization and transportation in the form of environmental degradation and extra financial costs on health sector. There are high number of diseases which are caused by exposure to vehicular emissions, mainly in children and people suffering from cardiovascular and chronic disorders. Impact of disease depends on the frequency and duration of exposure. It starts a vicious cycle by aggravating human's illness, causing a decline in their quality of life, and making it difficult for them to live an ordinary life.

Transport sector is very important for Pakistan's economy. It contributes to 10% of GDP and 17% GCF. Approximately 2.3 million people are engaged to this sector as employed labor force. Number of vehicles has increased at rapid rate in Pakistan mainly due to following factors:

- Economic growth
- Population boom
- Urban sprawl and
- Improvement in living standard of common man (Sindhu, 2008).

Table: 1.1

Motor vehicle growth in Pakistan, 1975–2005
(Motor vehicle numbers in millions)

Year	Trucks	Buses	Cars	M2W Vehicle	Others	Total vehicles
1975	0.220	0.05	0.280	0.05	0.110	0.71
1985	0.600	0.16	0.86	0.28	0.192	2.092
1995	3.50	1.32	3.60	6.3	1.200	15.92
2005	4.00	2.10	8.29	20.50	2.700	37.59

* others include tractors, trailers, M3W and miscellaneous vehicles.
Source: (Ilyas, 2007)

Table 1.1 shows motor vehicle growth over three decades from 1975 to 2005 in Pakistan. It shows that the number of vehicles has drastically increased during last two decades as we can see in 1985, there were 2.092 million vehicles which increased to 15.92 million and further increased in 2005 as 37.59 million which certainly shows the tremendous increase in vehicle use in Pakistan. Table 1.2 shows the decade wise growth rate of vehicles. In first decade the growth rate of motor vehicles was 39.46% which increased to 86.09% in second decade, which shows tremendous increase in motor vehicles production in Pakistan.

Table: 1.2

Decade wise growth rate (%), of all motor vehicles & M2W vehicles.

Years	Growth rate (%)	M2W vehicles
1975-1985	39.46	66
1985-1995	86.09	20.71
1995-2005	33.61	693.33

Source: Ilyas, 2007

Hence, it is an urgent need that Government, NGO's and urban transport administration should pay attention to this serious issue.

According to WHO fact sheet, Asthma (respiratory disease) is on the rise and costs each country millions of dollars in medication and this cost exceeds the cost of HIV/AIDS combined worldwide.

In the current study, two cities were selected i-e Islamabad and Muzaffarabad. In each city, three types of fuel emissions were studied including Diesel, CNG and Petrol emissions. In Islamabad and Muzaffarabad, the number of cars has been increasing at rapid pace (Pak-EPA, 2008). But our concern was not the number of vehicles rather it was the quality of vehicular emissions, the most important factor to be studied.

In Muzaffarabad, large number of vehicles is commercial and Government owned and most of the vehicles are diesel driven. Data recorded would help in assessing success of control measures in both cities. No one can judge the future trend of emission level but can give rough estimate. It is getting worst day by day. It is necessary to accomplish goals by proper implementation of standards to ensure improved environmental quality

especially that of air. Research has shown that by strict implementation of regulations for two to three years, air quality has rapidly improved as compared to past four years in Pakistan (Pak EPA).

1.2 Vehicular Emissions:

During past few years, vehicular emissions have become the center of attention. Each fuel type has been used in various sectors of transportation. Globally, transport consumes nearly 49 percent of fossil fuels but diesel is mostly used in heavy traffic for fright transport in urban environment. Diesel vehicles are considered as better option over petrol cars due to their economical value and lesser maintenance requirements (ARIC, 2000). However each fuel type has different exhaust emissions. There is an increased trend of environmental issues & associated disease cases have been reported in rapidly growing urban cities of UK. Emission levels increase with age of vehicle and distance travelled. Older vehicles usually have higher level of emissions, but their contribution to overall air degradation is less mainly due to less distance travelled (FORS, 1996).

There is an ambiguity in deciding which fuel type is better because of the fact that each fuel type poses certain threat to environment with harmful exhaust emissions and also because there is a lack of measurement methods in emission monitoring (ARIC, 2010). Hydrocarbon is produced from evaporation of petrol, incomplete combustion process, leakage of natural gas and volatile compounds, used in paints and industries.

1.3 Petrol:

Petrol is liquid mixture obtained from petroleum. Chemically it is mostly consisted of aliphatic and aromatic hydrocarbons that are toluene and benzene. During fractional distillation process, petroleum is refined at different temperatures and petrol is obtained

as byproduct at temperature between 35 to 200 C^o. Energy content of petrol is 34.6 Mj/l. In Pakistan, 130 billion liter of petrol is consumed annually, while in US it is 510 billion liters (138 billion gallons) (Diffen, 2010). According to climate group report, petrol usage as fuel has decreased by two percent in Australia during past two years. Main reason for this is global financial crisis (Climate Group report, 2009). An US EPA study shows that maintenance cost of petrol vehicle is 15 percent less than the diesel vehicles (US EPA, 2002).

1.3.1 Petrol emissions:

Emissions from petrol vehicles are mainly CO and HC, while production of oxides of nitrogen and particulate matter are much lower in concentration. For this reason NO_x and particulate matter are not measured in vehicular emission testing to check compliance (Diffen, 2010). Each country has defined limits for petrol vehicle emissions. In Pakistan, emission limits are set according to vehicle age and type. According to climate group report, emissions from petrol vehicles contribute 20 percent of all green house gases present in air in Australia (climate group report, 2009)

Table: 1.3

Emissions for Road Vehicles (per vehicle kilometer)

Vehicles	CO	HC	Nox	PM	CO_2
Petrol Cars	100	100	100	.....	100
Diesel Car	2	3	31	100	85

Source: Air Pollution & Acid Rain Fact Sheets Series; motor vehicle emission controls, UK.

* Petrol cars without catalysts have been given a relative value of 100 for comparison

Petrol vehicles produce more CO and HC per mile as compared to diesel vehicles. Table 1.3 shows that petrol car emits 100 times emissions per kilometer of CO, HC, Nox and Co_2, while the diesel car emits relatively less emissions of CO, HC and NOx emissions excluding PM and CO_2 which have higher values of 100 and 85, respectively. Petrol engines produce more carbon monoxide but much less particulate matter than diesel engines (Health and Safety Executive, 1999).

1.4 Diesel:

Diesel is a product of petroleum derived through fractional distillation invented by Germen Engineer Rudolf Diesel. Diesel is obtained at temperature range between 250 to 350 C^o. Petrol is produced earlier in the process of fractional distillation than diesel because it is derived at lower temperature. Engine run by diesel is more efficient. Chemically, diesel consists of 75% saturated hydrocarbons and 25% aromatic hydrocarbons. The average energy content of diesel is 38.6 MJ/l (Diffen, 2010). Due to above mentioned properties; diesel is more efficient fuel as compared to petrol. Diesel gives 1.5 times more fuel efficiency than petrol. Major portion of transportation uses diesel as fuel. For this reason diesel is subsidized in many countries such as India. Particulate emissions from diesel engine are one of the worst environmental hazards (Pak- EPA, 2008).

1.4.1 Diesel Emissions:

Diesel vehicles produce more noxious gases and particulate matter as compared to CO and HC. The soot quantity in smoke varies from 60% to 80% depending on type and age

of engine. Most of the contaminants are adsorbed onto the soot (Health and Safety Executive, 1999). Hence diesel vehicles are tested for soot content or particulate matter regarding vehicular emissions. To check the level of particulate matter in diesel smoke, certain parameters are set, such as opacity. Higher the opacity, greater will be the particulate matter concentration in smoke. Different countries have defined different limits for diesel vehicles opacity. In this regard, Pakistan also explained standards for vehicular emissions. These limits are set according to vehicle type and age. [See Annex-1].

Breathing in diesel fumes can affect human health; short term exposure to diesel fumes can cause irritation of eyes or respiratory tract. While, long term exposure to diesel fumes could lead to coughing and breathlessness (Health and Safety Executive, 1999).

1.5 CNG:

Due to harmful emissions from petrol and diesel vehicles, there is emerging trend of green fuels all over the world and these fuels are called as alternative fuel source for the vehicles. The alternate fuel sources are being introduced day by day to combat hazardous effect of emissions (Diffen, 2010). In this regard various fuel types such as compressed natural gas, liquefied petroleum gas, alcohol fuel and hydrogen are being tested. Among all alternate fuels, CNG is most commonly used. A study conducted by US-EPA found that operating costs for CNG vehicles were 25 percent less than the gasoline-powered vehicles (US EPA, 2002).

1.5.1 CNG Emissions:

Emissions from CNG vehicles mainly contain HC and CO due to the presence of methane; NOx and PM are lower in CNG. NO_x level in CNG emissions is half of the

concentration as compared to petrol vehicles. Above statement shows that CNG vehicles are significant contributors to global warming. Bulk transporter study in California showed that emissions from CNG buses were more toxic than diesel and formaldehyde levels in CNG vehicle emissions were much higher than diesel vehicle emissions. (Bulk transporter study, 2002)

1.6 Objectives:

The main purpose of this study is to conduct an exploratory research for phasing out vehicular emission trend. To accomplish this, the research will attempt to address the following specific objectives:

- To compare vehicular emission levels of Islamabad and Muzaffarabad.
- To check number of vehicle compliance with standards.
- To check type of fuel mostly used in cities.

1.7 Limitations

Vehicular emission is a problem with wide range of impacts observed all over the country. It isn't possible to address all the affected people country wide, therefore; only two cities i.e Islamabad and Muzaffarabad were focused and studied for vehicular emission levels and compliance in both cities.

CHAPTER 2

REVIEW OF LITERATURE

The rapid growth in urbanization and motorization had resulted in socially, economically, and environmentally unsustainable use of land and transport system. (Intikhab and Huapu, 2007)

There are so many pollutants arise from vehicular emissions but mainly CO, CO_2, oxides of nitrogen and hydrocarbons are studied for formulating permissible limits. According to latest research, air pollution mainly contributor to photochemical pollution which have long term adverse effect on children respiratory health (Pak-EPA Air Quality Emissions Standards Recommendations report).

According to climate group report, emissions from petrol vehicles contribute 20 percent of all green house gases present in air in Australia (climate group report, 2009)

Opacity was introduced in Euro III emissions standards as vehicular testing criteria measurement. In diesel smoke particulate matter are considered as liable for opacity. (Lapuerta *et al.*, 2005)

Level of emissions increase with age of vehicle and distance travelled. Vehicle 10-16 years old produce emissions with high concentration of CO and HC. It has been observed that old vehicles do produce a high level of hazardous emissions but their contribution to annual air pollution is less. This is mainly because of reduced distance travelled. It is evident from the study that well tuned and maintained vehicles produce 9-25 % less emissions from normal emissions. Regular tuning can decrease fuel consumption and lower in emissions. (Motor Vehicle pollution in Australia report, 1996)

Emissions of an engine depend on fuel type, temperature and use of engine type. In normal state, the byproducts of fuel are water and CO_2, while in idling and slow moving car, the major emission is CO due to incomplete combustion. It is observed that of all CO_2 in urban atmosphere, three quarters are mainly contributed from transport sector. Another environmental pollutant is particulate matter. It is emitted from various sources including transport (25%), industrial plants (17%), residential combustion (16%), power generation (15%) and non combustive processes (24%) (ARIC, 2000).

Bulk transporter study in California showed that emissions from CNG buses were more toxic than diesel. And formaldehyde levels in CNG vehicle emissions were much higher than diesel vehicle emissions. (Bulk transporter study, 2002) Breathing in diesel fumes can affect human health; short term exposure to diesel fumes can cause irritation of eyes or respiratory tract. While, long term exposure to diesel fumes could lead to coughing and breathlessness (Health and Safety Executive, 1999).

The impact of urban environmental hazard is more immediate on health than on income. The implementation of environmental laws seems to be inadequate or incapable to control urban pollution, hence public faces complex of environmental issues. (Jokes *et al.*, 1996).

In 115 European cities, nearly 40 million people inhale air that is above the WHO air quality standards. The extent of any significant environmental impact on people is measured in terms of health risk to people. (Schultz *et al.*, 2001).

Number of vehicles has increased at rapid rate in Pakistan mainly due to following factors: Economic growth, Population boom, Urban sprawl and Improvement in living standard of common man. In 1990, total registered vehicles was 27, 12,837. In 2006, this value increased to 62, 10,769 with increasing trend was about 129%. Nearly 35% of commercial energy is used by

transport sector annually. Transport sector receives annually 20-25 % of public sector development fund (Sindhu, 2008).

With increase in motor vehicles number in Pakistan, the challenge is to minimize environmental impact. To work for providing motorization and minimizing, its impacts require considerable resources (Zafar, 2007).

Profitable and environmentally safe and sound vehicle drive in urban environment can be achieved by cutting cost and increasing vehicle efficiency.

The quality of transport service in slum areas adversely affects the local environment through noise and vehicular emissions. which can result in long term ill health effects. The decline in transport services is due to old and over aged vehicles and reduction in import of spare parts from overseas. As cities are growing rapidly due to urbanization, jobs are scattered across large areas so it is difficult to locate job at home vicinity (Sohail *et al.,* 2005).

Significant improvement in air quality has been observed by decreasing transport emission in many European countries. Transportation is main contributor of Nox and CO at urban locations. While decreasing trend of PM did not directly relate to vehicular emissions, because many other sources directly or indirectly contribute to PM concentration in air. (Krzyzanowski M., 2005).

In US motor vehicles are responsible for 60% of benzene and 39% of

Acetaldehyde emissions in air pollution. Establishing health based air quality standards will help in improving air condition. This approach would also help in assessing public health and risk management (Charnley and Goldstein, 1998).

Chapter 3

Material and Methods

The methods for information and data collection included interviews and analysis of content, review of literature and focus group discussions.

As nature of problem is very broad and its effects are widely seen, for current study two cities of Pakistan were focused which are Islamabad and Muzaffarabad.

Environmental officials in various departments were interviewed. These officials are responsible for emission standards implementation, emission testing, vehicular compliance and issuing challan or warning. The valuable information was collected and helped in the analysis of data and result derivation. The data for energy consumption by transport section and total vehicle number in both cities was collected by interviewing ENERCON officials. This data helped in analyzing vehicle density in both cities and respective vehicular emissions. The information for vehicular emission testing method (when program was started and which instrument was used and how data was recorded) was gathered by interviewing the officials at Environmental Protection Agency. Data for Vehicle type was also gathered to check most frequent mode of transport in city.

Besides interviews, quantitative secondary data was collected from EPA. Vehicular emission data for Islamabad and Muzaffarabad was collected from Federal Environmental Protection Agency (FEPA). Latest one year monthly data for vehicular emissions and compliance was also collected from EPA. This

helped in calculating average value of vehicular emissions for each month, which further helped in comparative analysis of two cities. Fuel type data was collected for each city to see which fuel type is mostly used in both cities (collected from EPA). The data was according to fuel type used by vehicle, month of checking, compliance to standards, respective emissions and emission level and final remarks which showed current status of vehicle either with emissions within or above the limits. The data was analyzed to check vehicles using by different fuel types; to check compliance, whether fuel type contributed to varying degree of hazardous emissions and monthly fuel use frequency in each city.

The study was conducted on motorized vehicles such as buses, trucks, vans, shehzores, cars, jeeps, suzukis, tractors, rickshaws. These vehicles were also studied for the fuel type i.e diesel, petrol and CNG. The potential emissions were carbon monoxide and hydrocarbon. For diesel vehicles, opacity was measured in percentage. Both quantitative and qualitative approaches were used for analysis and fact finding. Significant information was sought from regulatory agencies such as EPA and ENERCON. Other secondary data sources include published and unpublished reports specifically of traffic management, vehicular emissions, regulations and policies. Population statistics of study areas was also taken from federal bureau of statistics Islamabad. The data for different variables was analyzed statistically and association among different variables was worked out along with projections for future years.

Analysis:

Analysis of data was done using SPSS and MS- Excel software.

Chapter 4

RESULTS AND DISCUSSIONS

Vehicular emission data for Islamabad was of five months i.e February, March, April, May and August 2009. In Islamabad total vehicles studied were 2,503.Three types of fuel data was available that is for CNG, diesel and petrol. This data was analyzed to check compliance, hazardous emission level and fuel frequency in city. Analyzed results for vehicular emissions are presented below;

Table 4.1

Relationship among three variables for fuel type and compliance

Compliance			**Fuel**			**Total**
			Diesel	**Petrol**	**CNG**	
Yes	Month	Feb	339	0	18	357
		March	581	1	33	615
		April	441	2	104	547
		May	55	0	0	55
		Aug	313	114	0	427
	Total		1729	117	155	2001
No	Month	Feb	121	0	0	121
		March	152	4	2	158
		April	100	1	5	106
		May	11	0	0	11
		Aug	91	13	0	104
	Total		475	18	7	500

Table 4.1 explains the overall case summary for Islamabad. It exhibits the relationship among three variables compliance, fuel type and monthly emissions level. During month of February 2009, 339 diesel and 18 CNG vehicleswere in compliance to standards. In March 581 diesel, 1Petrol and 33 CNG vehicles had green stickers and in month of April, 441 diesel vehicles, 2 petrol vehicles and 104 CNG vehicles were in compliance, while in May only 55 diesel vehicles had emission levels below limits. In August, 114 petrol vehicles and 313 Diesel vehicles emitted emissions below standards. As a whole, 1729 diesel, 117 petrol and 155 CNG vehicles were in compliance to standards. Out of total 2503 vehicles 2001 vehicles, observed compliance to the standards. Lower portion of the table describes the ratio of vehicles which were not in compliance to vehicular limits. In month of February, only 121 diesel vehicles emission exceeded the limits. In month of March 152 diesel vehicles, 4 petrol vehicles and 2 CNG vehicles were not in compliance to standards. In April, 100 diesel vehicles, 1 petrol vehicle and 5 CNG vehicles had higher level of emissions, while in May only 11 diesel vehicles had emissions above the limits. Lastly in the month of August, 91 diesel and 18 petrol vehicles got red sticker. As a whole 475 diesel, 18 petrol and 7 CNG vehicles were not in compliance to standards. And out of 2503 total vehicles studied, 500 vehicles produced emissions which were above permissible limits.

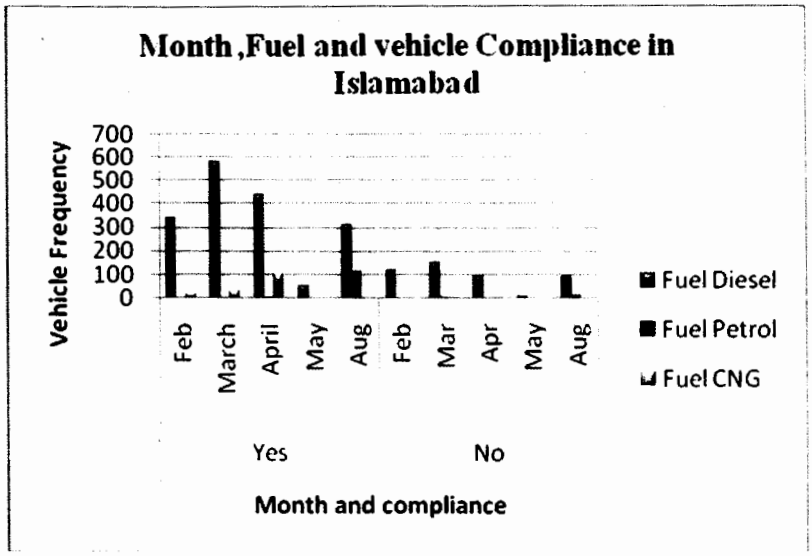

Fig 4.1: Shows vehicle compliance, fuel type with respect to month.

Table 4.2

Vehicle monitoring frequency

		Frequency (n= number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Feb	478	19.1	19.1	19.1
	March	773	30.9	30.9	50.0
	April	653	26.1	26.1	76.1
	May	66	2.6	2.6	78.7
	Aug	533	21.3	21.3	100.0
	Total	2503	100.0	100.0	

It exhibits number of cars monitored for vehicular emission in different months. According to table 4.2, 478 vehicles in February, 773 in March, 653 in April, 66 in May and 533 in August were tested for compliance to standards. A total of 2503 vehicles

were checked. Out of this,19 percent of vehicles were tested in February, 30.9 percent in March, 26.1 percent in April, 2.6 percent in May and 21.3 percent in August.

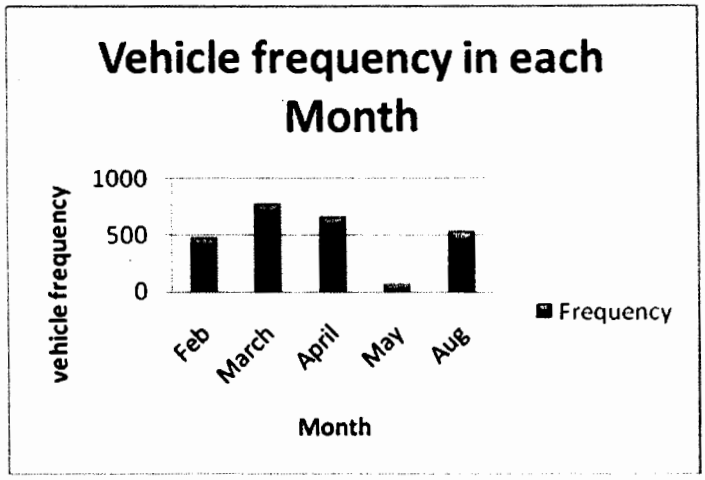

Fig 4.2: Shows the frequency of vehicles with respect to month.

Table 4.3

Frequency of fuel type used

		Frequency (n= number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Diesel	2204	88.1	88.1	88.1
	Petrol	136	5.4	5.4	93.5
	CNG	162	6.5	6.5	100.0
	Total	2502	100.0	100.0	
Missing	System	1	.0		
Total		2503	100.0		

Table 4.3 shows the frequency of fuel type, total vehicles studied. According to table, 2204 vehicles were diesel driven, 136 vehicles petrol driven and 162

vehicles used CNG as fuel, while fuel type of one vehicle was not known. As a whole, 88.1 percent of vehicles used diesel, 5.4 percent used petrol and 6.5 percent of vehicles used CNG as fuel.

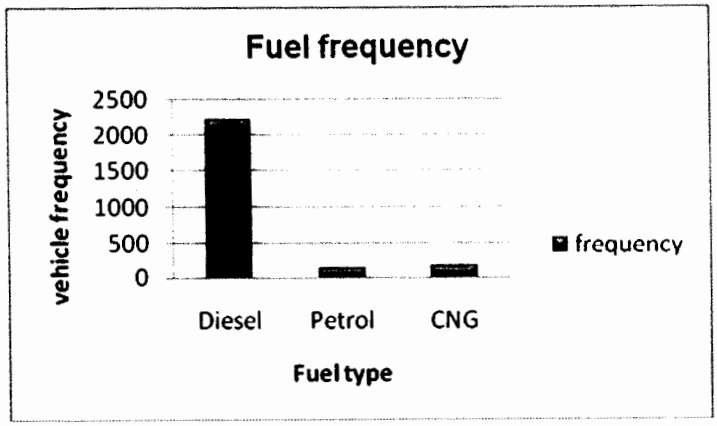

Figure: 4.3 Presents fuel frequency in Islamabad.

Table 4.4

Vehicle frequency by compliance in Islamabad.

		Frequency (n=number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Yes	2002	80.0	80.0	80.0
	No	500	20.0	20.0	100.0
	21.00	1	.0	.0	100.0
	Total	2503	100.0	100.0	

Table 4.4 explains the vehicular frequency by compliance in Islamabad. Out of 2503 total vehicles studied, 2002 were in compliance to standards while 500 vehicles were not

following the limits. As a whole, 80 percent of vehicles produced emissions within the limits while 20 percent of vehicles produced emissions above permissible limits.

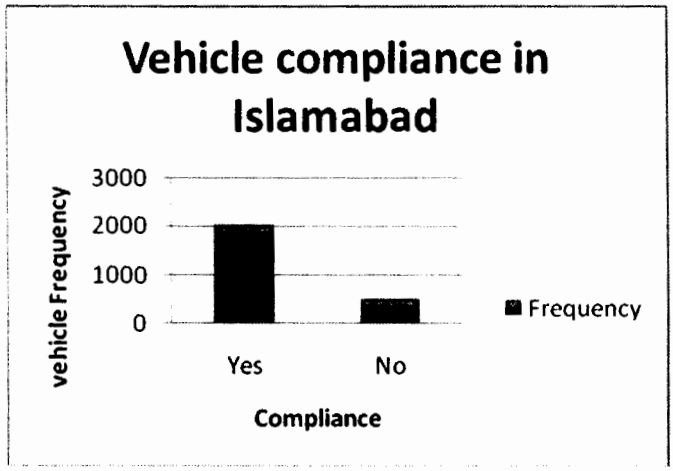

Fig 4.4: Presents Vehicle compliance in Islamabad

Table 4.5

Emissions from Diesel vehicles (Opacity)

Sr. no	Class Interval (%)	Frequency (n= number of vehicles)
1.	1-10	488
2.	11-20	869
3.	21-30	314
4.	31-40	143
5.	41-50	176
6.	51-60	112
7.	61-70	58
8.	71-80	29
9.	81-90	14
10.	91-100	2
	Total	2205

Table 4.5 shows opacity, measured in terms of percentage. In Islamabad, 2205 vehicles

were checked for this variable. To make study more significant, class intervals were defined for opacity. First class interval made for vehicles had opacity "between" 1-10. Four hundred and eighty eight (488) vehicles had opacity within first interval and 869 vehicles had opacity within second interval. Three hundred and fourteen (314) vehicles within 21-30 class interval and 143, 176, 112, 58, 29, 14 and 2 vehicles had opacity percentage in successive class interval.

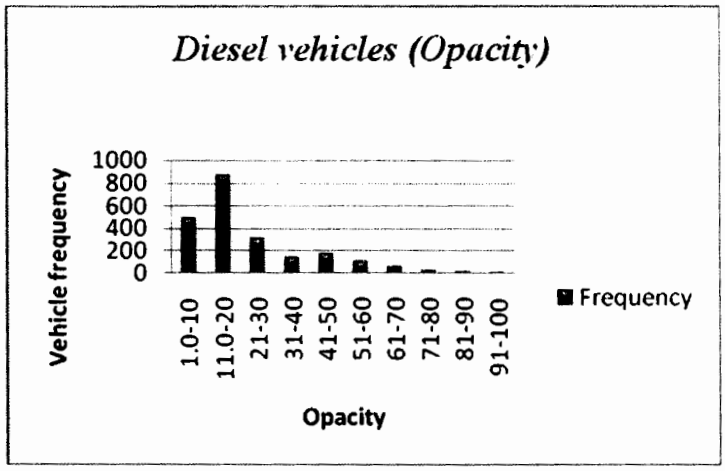

Fig 4.5: Shows Opacity percentage of Diesel vehicles in Islamabad.

Table 4.5.1

Diesel vehicles compliance in Islamabad

compliance	Non compliance	Total checked vehicles
1814	391	2205
82%	17.7%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for opacity is 40%. Vehicles having opacity level beyond permissible limit will be given red sticker and charged. Out of total vehicles studied for

opacity (2205), one thousand and twenty five (1725) vehicles had opacity under the permissible limits and four hundred and eighty (480) vehicles were not observing the limits.

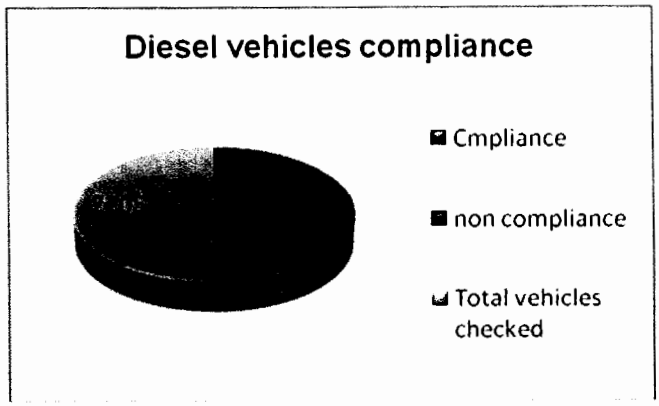

Figure 4.5.1 shows diesel vehicles compliance in Islamabad

Table 4.6

Petrol Vehicles: Hydrocarbon emissions

Sr. no	Class Interval (ppm)	Frequency (n=number of vehicles)
1.	0.00-200	78
2.	201-400	32
3.	401-600	17
4.	601-800	3
5.	801-1000	4
6.	1001-1200	0
7.	1201-1400	0
8.	1401-1600	0
9.	1601-1800	2
	Total	136

For petrol vehicles, compliance was checked with HC and CO concentration in smoke. Table 4.6 presents the HC level and vehicle frequency in respective intervals. Nine (9)

class intervals were defined for HC emission levels each with 200 intervals. In first class interval 78 vehicles were recorded. Second interval included 32 vehicles and 17 vehicles recorded for third interval. 4th & 5th class interval included 3 and 4 vehicles, respectively. While 2 vehicles fell in last interval.

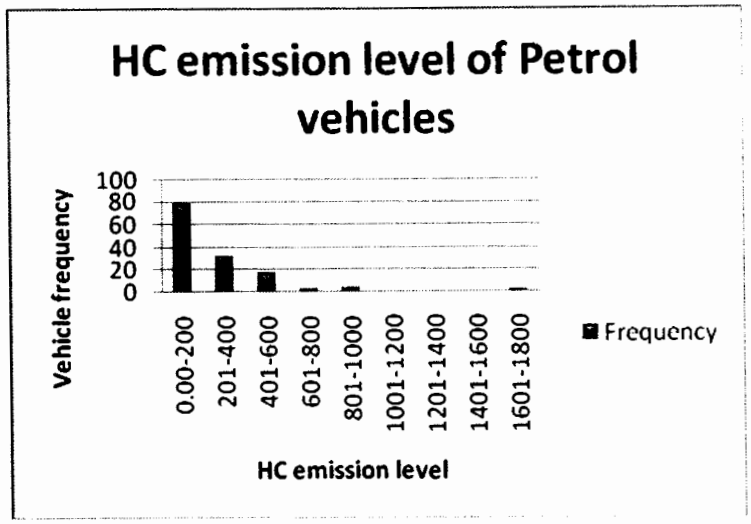

Fig 4.6 Shows HC level in Petrol Vehicles.

Table 4.6.1

Petrol vehicles compliance in Islamabad

compliance	Non compliance	Total checked vehicles
118	18	136
82%	17.7%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for hydrocarbon is 450ppm. Vehicles having hydrocarbon level beyond permissible limit will be given red sticker and charged. Out of total vehicles

studied for hydrocarbon (136), one hundred and eighteen (118) vehicles had HC level under the permissible limits and eighteen (18) vehicles were not observing the limits.

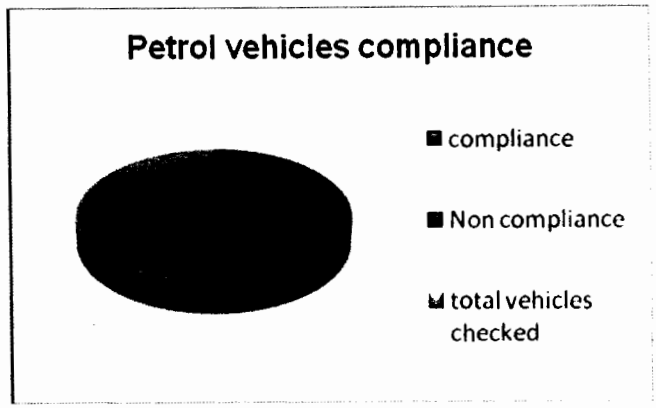

Figure 4.6.1 shows petrol vehicles compliance in Islamabad

Table 4.7

CO level of petrol vehicles in Islamabad

Sr. no	Class Interval (%)	Frequency(n= number of vehicles)
1.	0.00-0.99	90
2.	1.00-1.99	35
3.	2.00-2.99	8
4.	3.00-3.99	3
	Total	136

Table 4.7 shows vehicle frequency for CO emission. Class intervals have been defined with 0.99 differences. 90, 35, 8 and 3 vehicles fall in respective four intervals. Total 136 petrol vehicles were studied for CO emissions. Highest number of vehicles fall in 1st interval (0.00 to 0.99).

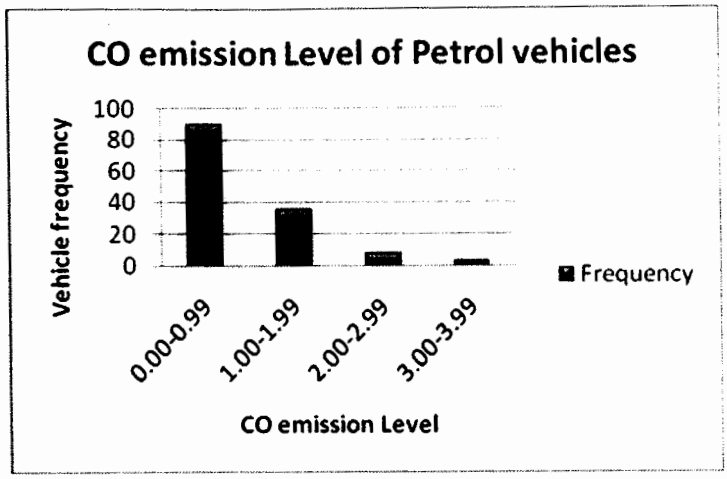

Fig 4.7 Presents CO level of Petrol Vehicles in Islamabad

Table 4.7.1

Petrol vehicles compliance

compliance	Non compliance	Total checked vehicles
132	4	136
97.1%	2.9%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for carbon monoxide is 2.5%. Vehicles having carbon monoxide level beyond permissible limit will be given red sticker and charged. Out of total vehicles studied for carbon monoxide (136), one hundred and thirty two (132) vehicles had CO level under the permissible limits and four (4) vehicles were not observing the limits.

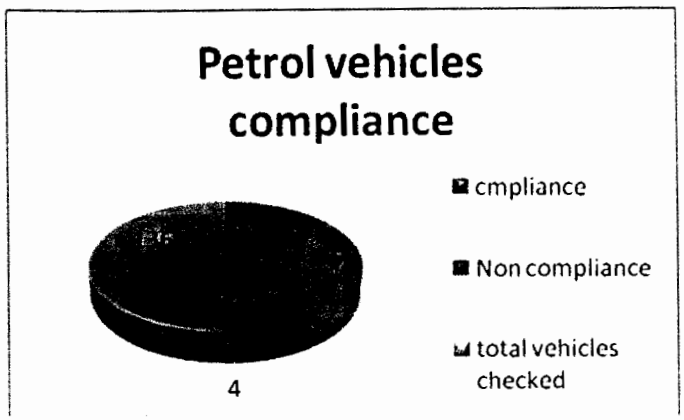

Figure 4.7.1 shows petrol vehicles compliance

Table 4.8

HC level of CNG vehicle in Islamabad

Sr. no	Class Interval (ppm)	Frequency (n=number of vehicles)
1.	0.00-500	157
2.	501-1000	2
3.	1001-1500	2
4.	1501-2000	2
	Total	163

Table 4.8 shows emmissions of CNG vehicles. Intervals were defined for HC emissions. In interval between 0.00-500, 157 vehicles fall and sucessively, all 3 intervals had 2 vehicles each.

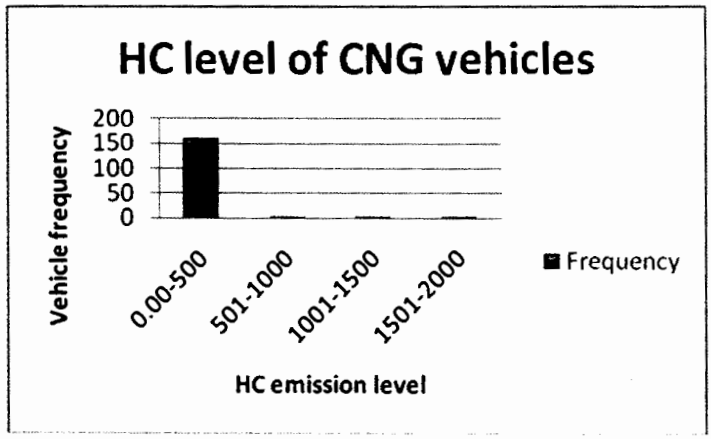

Fig 4.8: presents HC level of CNG vehicles in Islamabad

Table 4.8.1

CNG vehicles compliance in Islamabad

compliance	Non compliance	Total checked vehicles
156	7	163
95.7%	4.3%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for hydrocarbon is 450ppm. Vehicles having hydrocarbon level beyond permissible limit will be given red sticker and charged. Out of total vehicles studied for hydrocarbon (163), one hundred and fifty six (156) vehicles had HC level under the permissible limits and seven (7) vehicles were not observing the limits.

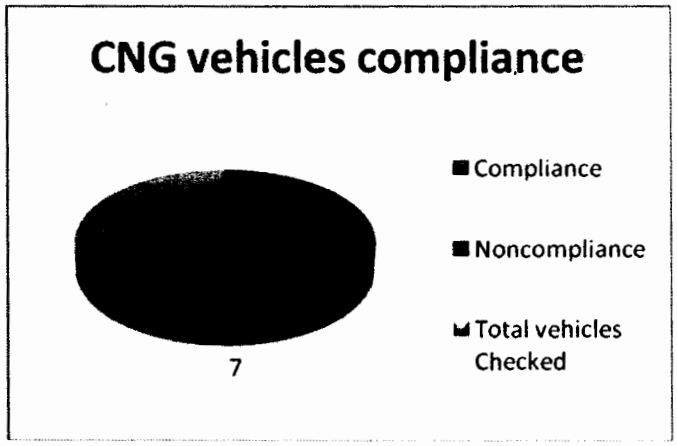

Figure 4.8.1 shows CNG vehicles compliance

Table 4.9

CO level of CNG vehicles in Islamabad.

Sr. no	Class interval (%)	Frequency (n= number of vehicles)
1.	0.00-0.99	97
2.	1.00-1.99	55
3.	2.00-2.99	7
4.	3.00-3.99	3
5.	4.00-4.99	1
	Total	163

Total 4.9 shows that total 163 vehicles were studied for CO level in Islamabad. Interval with 0.99 differences was defined. The first interval has 97 vehicles, 55 in second and 7, 3 and 1 in successive intervals. Highest number of vehicles fell in 1st interval (between 0.00-0.99).

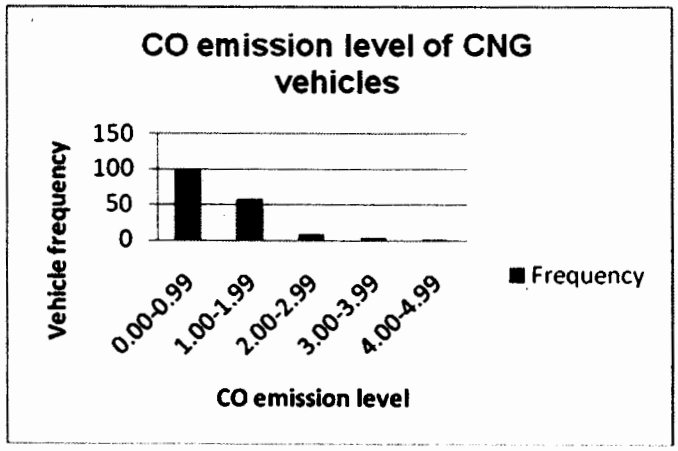

Fig 4.9 Shows CO level of CNG vehicles in Islamabad

Table 4.9.1

CNG vehicles compliance in Islamabad

compliance	Non compliance	Total checked vehicles
159	4	163
97.5%	2.5%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for carbon monoxide is 2.5%. Vehicles having carbon monoxide level beyond permissible limit will be given red sticker and charged. Out of total vehicles studied for carbon monoxide (163), one hundred and fifty nine (159) vehicles had CO level under the permissible limits and four (4) vehicles were not observing the limits.

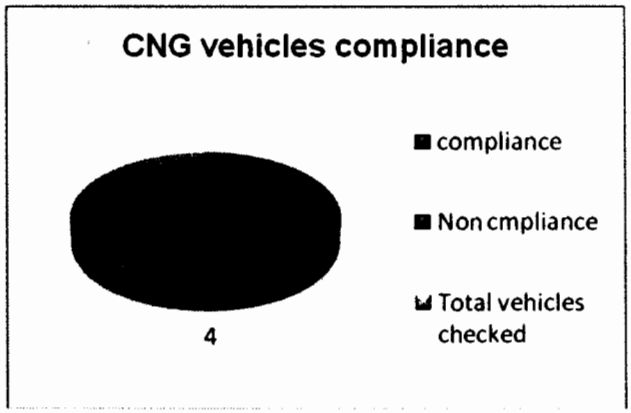

Figure 4.9.1 shows CNG vehicles compliance in Islamabad

Results and Discussion on vehicular emissions in Muzaffarabad

Data for Muzaffarabad was of two months i.e October and November 2010. The variables including fuel type, vehicle type and compliance. Total vehicles studied were 483 and necessary information regarding all vehicles was available for analysis and interpretation of results. The studied motorized vehicles in Muzaffarabad included, buses, trucks, vans, shehzores, cars, jeeps, suzukis, tractors and rickshaws. These vehicles were also studied for fuel type including diesel, petrol and CNG. The potential emissions are carbon monoxide and hydrocarbon. For diesel vehicles, opacity was measured in percentage. Analyzed data and study findings for Muzaffarabad are as follows;

Table 4.10

Cross tabulation among Month, fuel and compliance for Muzaffarabad

Compliance			Fuel		Total
			Diesel	Petrol	
Yes	Month	Oct	18	15	33
		Nov	161	9	170
	Total		179	24	203
No	Month	Oct	28	31	59
		Nov	216	5	221
	Total		244	36	280

Table 4.10 give the whole summary of the study showing that 18 diesel vehicles, 15 petrol vehicles in October and 161 diesel & 9 petrol vehicles in November, were in compliance to standards. In both months, 179 diesel and 24 petrol vehicles had emissions below permissible limits and 216 diesel and 5 petrol vehicle emissions exceeded the limits. As a whole, out of 483 vehicles studied, 203 were in compliance to standards while 280 vehicles had emissions above the permissible limits as defined in standards.

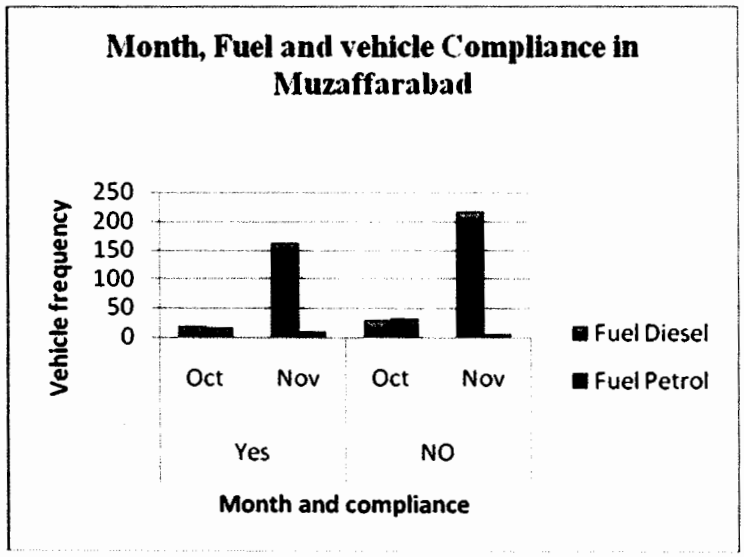

Fig 4.10 Presents cross tabulation among Month, fuel and compliance.

Table 4.11

Vehicle, fuel and compliance in Muzaffarabad.

Compliance			**Fuel**		**Total**
			Diesel	Petrol	
Yes	Vehicle	Bus	8	0	8
		Truck	62	0	62
		Van	73	0	73
		Shehzore	2	0	2
		Car	11	11	22
		Jeep	21	3	24
		Suzuki	1	9	10
		Tractor	1	0	1
		Rickshaw	0	1	1
	Total		179	24	203
No	Vehicle	Bus	11	0	11
		Truck	38	0	38
		Van	96	1	97
		Shehzore	3	0	3
		Car	42	16	58
		Jeep	54	1	55
		Suzuki	0	15	15
		Rickshaw	0	3	3
	Total		244	36	280

Table 4.11 Exhibits vehicle type, fuel type and compliance. It explains that buses, trucks, vans, and Shehzores used only diesel as fuel and were in compliance to standards,

while 11 cars used diesel and 11 were run by petrol and their emissions were below the limits. Total 24 jeeps were in compliance to standards, out of which 21 used diesel and 3 used petrol. Total 9 Suzukis were run by petrol and only one used diesel, but all of them had below permissible limits.

Second part of the table shows the type of vehicles not in compliance to standards which included 11 buses, 38 trucks and 3 shehzores and 96 vans powered by diesel had emissions above permissible limits.

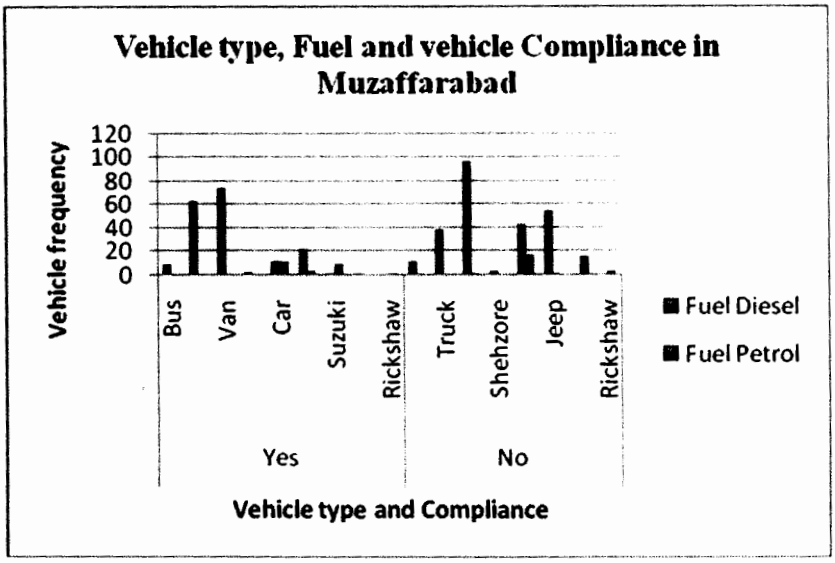

Fig 4.11 shows Vehicles, Fuel and Compliance.

Table 4.12

Vehicles studied with respect to month in Muzaffarabad.

		Frequency(n= number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Oct	92	19.0	19.0	19.0
	Nov	391	81.0	81.0	100.0
	Total	483	100.0	100.0	

Table 4.12 presents monthly vehicle frequency. Ninety two vehicles (92) vehicles were checked in month of October and 391 vehicles in November. As a whole, 19 percent of vehicles were tested in October for vehicular emissions 81 percent in November.

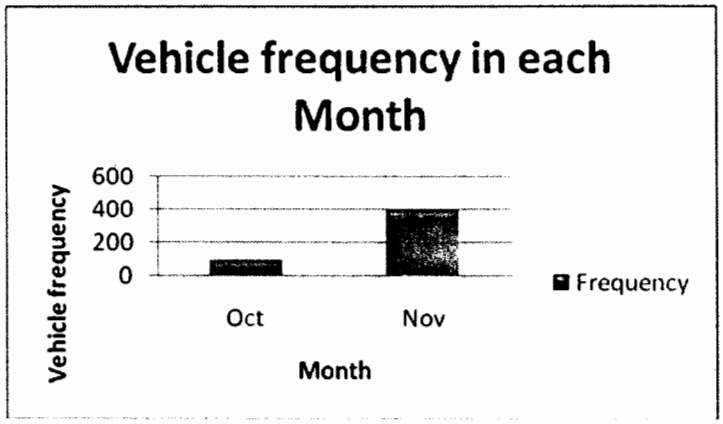

Fig 4.12 shows vehicles studied in October and November, 2009

Table 4.13

Frequency of fuel type used in Muzaffarabad.

		Frequency(n= number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Diesel	423	87.6	87.6	87.6
	Petrol	60	12.4	12.4	100.0
	Total	483	100.0	100.0	

Table 4.13 shows frequency of vehicles by fuel type used. Out of total 483 vehicles studied, 423 vehicles used diesel and 60 used petrol. It shows that 87.6 percent of vehicles in muzaffarabad used diesel and only 12.4 percent vehicles used petrol as fuel.

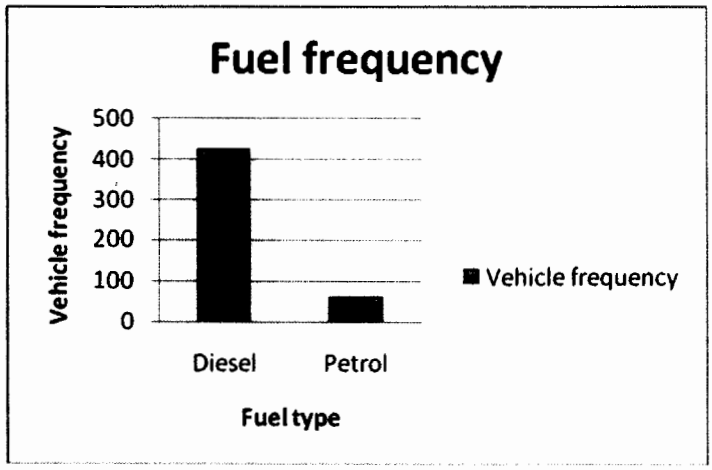

Fig 4.13 Shows frequency of fuel type used in Muzaffarabad.

Table 4.14

Vehicle compliance to standards in Muzaffarabad.

		Frequency(n= number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Yes	203	42.0	42.0	42.0
	No	280	58.0	58.0	100.0
	Total	483	100.0	100.0	

Table 4.14 shows vehicle frequency with reference to compliance to standards. Table total vehicles studied were 483, out of which 203 were in compliance to standards, while 280 vehicles produced emissions above the permissible limits. 58 percent of vehicles studied were not in compliance to standards and 42 percent observed standards.

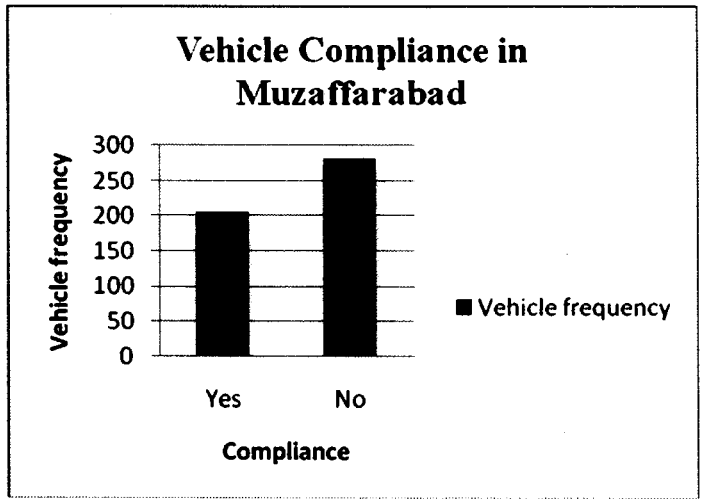

Fig 4.14 Shows Vehicle compliance to standards in Muzaffarabad.

Table 4.15

Frequency of vehicle type in Muzaffarabad.

		Frequency(n= number of vehicles)	Percent	Valid Percent	Cumulative Percent
Valid	Bus	19	3.9	3.9	3.9
	Truck	100	20.7	20.7	24.6
	Van	170	35.2	35.2	59.8
	Shehzore	5	1.0	1.0	60.9
	Car	80	16.6	16.6	77.4
	Jeep	79	16.4	16.4	93.8
	Suzuki	25	5.2	5.2	99.0
	Tractor	1	.2	.2	99.2
	Rickshaw	4	.8	.8	100.0
	Total	483	100.0	100.0	

According to table 4.15, total 19 buses (3.9%), 100 Trucks (20.7 %), 170 Vans (35.2%), 5 Shehzores (1%), 80 Cars (16.6%), 79 Jeeps (16.4%), 25 Suzukis (5.2%), 1 Tractor (0.2%), and 4 Rickshaws (0.8%) were studied.

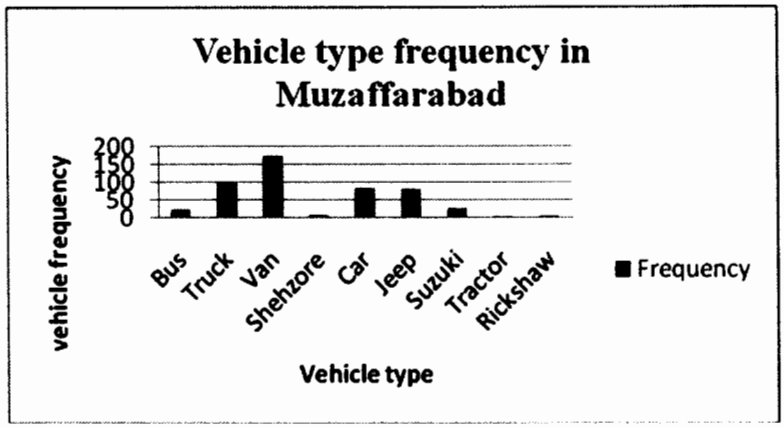

Fig 4.14 shows type of vehicles in Muzaffarabad

Table 4.16

Vehicle opacity level studied in Muzaffarabad

Sr. no	Class Interval (%)	Frequency(n= number of vehicles)
1.	1-10	34
2.	11-20	65
3.	21-30	52
4.	31-40	43
5.	41-50	53
6.	51-60	42
7.	61-70	44
8.	71-80	34
9.	81-90	28
10.	91-100	28
	Total	423

In Muzaffarabad, 423 diesel vehicles had been checked for opacity. 10 class intervals were defined with difference of 10. The highest number of 65 vehicles falls in interval between 11-20. Then 53 and 52 vehicles in 5th interval (between 41-50) and 3rd (21-30) respectively and then 44, 42, 34 vehicles in respective intervals. Last 2 intervals have a frequency of 28 vehicles.

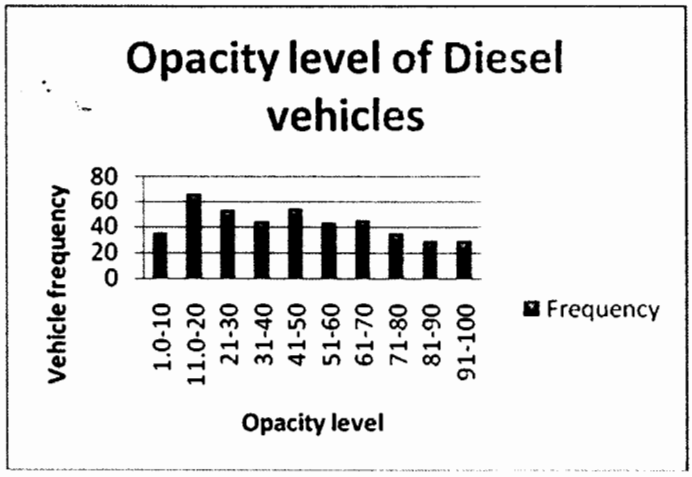

Fig 4.15 shows Opacity percentage measured of Diesel vehicles

Table 4.15.1

Diesel vehicles compliance in Muzaffarabad

Compliance	Non compliance	Total vehicles checked
229	194	423
52%	46%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for opacity is 40%. Vehicles having opacity level beyond permissible limit will be given red sticker and charged. Out of total vehicles studied for opacity (423), two hundred and twenty nine (229) vehicles had opacity under the permissible limits and one hundred and ninety four (194) vehicles were not observing the limits.

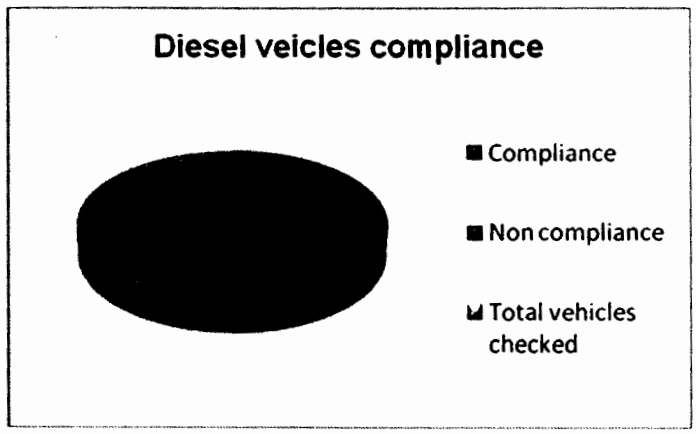

Figure 4.15.1 Shows diesel vehicles compliance in Muzaffarabad

Table 4.16

HC level of Petrol vehicles in Muzaffarabad

Sr. no	Class interval (ppm)	Frequency(n= number of vehicles)
1.	0.00-500	28
2.	501-1000	16
3.	1001-1500	4
4.	1501-2000	1
5.	2001-2500	3
6.	2501-3000	6
7.	3001-3500	1
8.	3501-4000	0
9.	4001-4500	0
10.	4500-5000	1
	Total	60

In Muzaffarabad, only petrol vehicles were studied. Hence, CO and HC emissions were recorded. HC level intervals were made. Maximum 28 vehicles were in interval between 0.00-500 and then 16 vehicles in second interval (5001-1000).

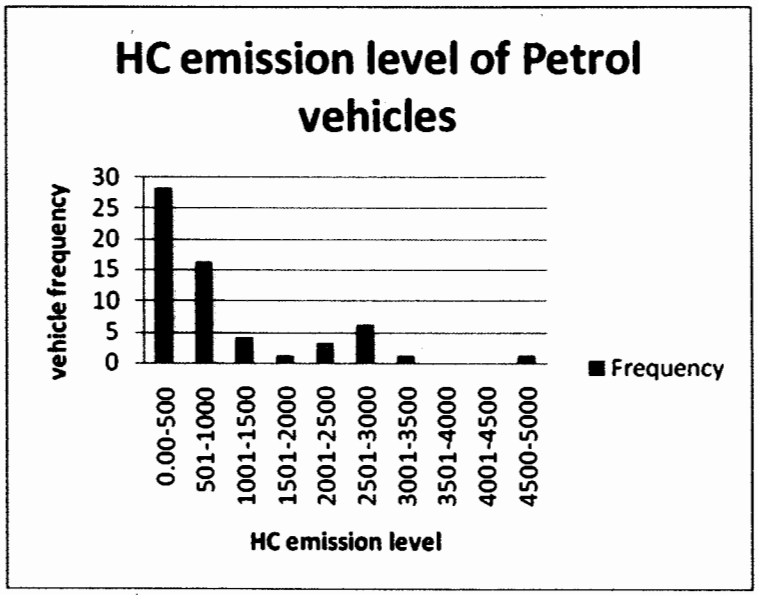

Fig 4.16 Shows Vehicle frequency with respect to HC level.

Table 4.16.1

Petrol vehicles compliance in Muzaffarabad

Compliance	Non compliance	Total vehicles checked
26	34	60
43.3%	56.7%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for hydrocarbon is 450 ppm. Vehicles having hydrocarbon level beyond permissible limits will be given red sticker and charged. Out of total vehicles studied for hydrocarbon level (60), twenty six (26) vehicles had HC level below permissible limits and thirty four (34) vehicles were not observing the limits.

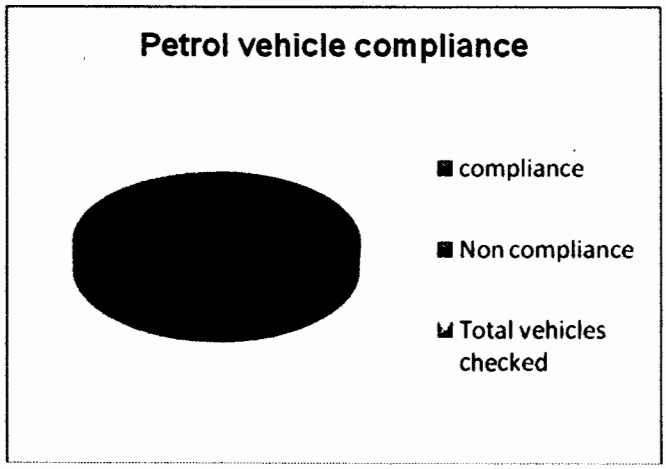

Figure 4.16.1 Shows petrol vehicles compliance in Muzaffarabad

Table 4.17

CO level of Petrol Vehicles in Muzaffarabad

Sr. no	Class Interval (%)	Frequency(n= number of vehicles)
1.	0.00-0.99	32
2.	1.00-1.99	14
3.	2.00-2.99	5
4.	3.00-3.99	3
5.	4.00-4.99	4
6.	5.00-5.99	1
7.	6.00-6.99	1
	Total	60

Table 4.17 shows vehicles studied for CO emissions. Highest number of vehicles, (32) fall in interval between 0.00-0.99 and then respective vehicle frequency is shown in above table.

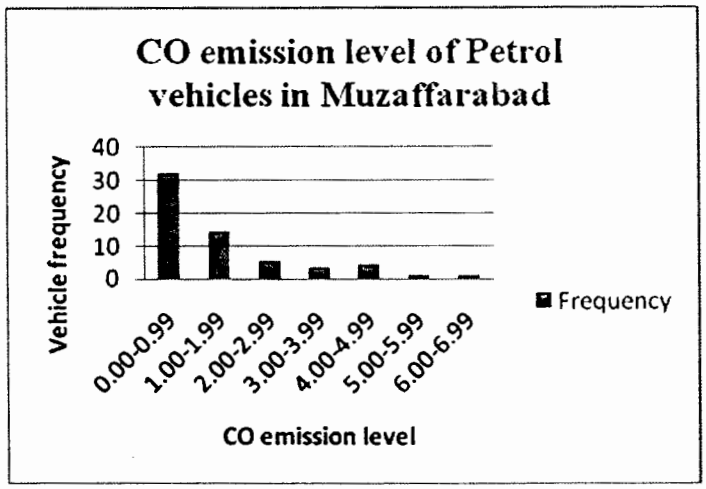

Fig 4.17 Shows CO level of petrol vehicles in Muzaffarabad.

Table 4.17.1

Petrol vehicles compliance in Muzaffarabad

Compliance	Non compliance	Total vehicles Checked
49	11	60
81.7%	18.3%	

According to national environmental quality standards for motor vehicles exhaust 1993; maximum permissible limit for carbon monoxide is 2.5%. Vehicles having carbon monoxide level beyond permissible limit will be given red sticker and charged. Out of total vehicles studied for carbon monoxide level (60), forty nine (49) vehicles had CO level under the permissible limits and eleven (11) vehicles were not observing the limits.

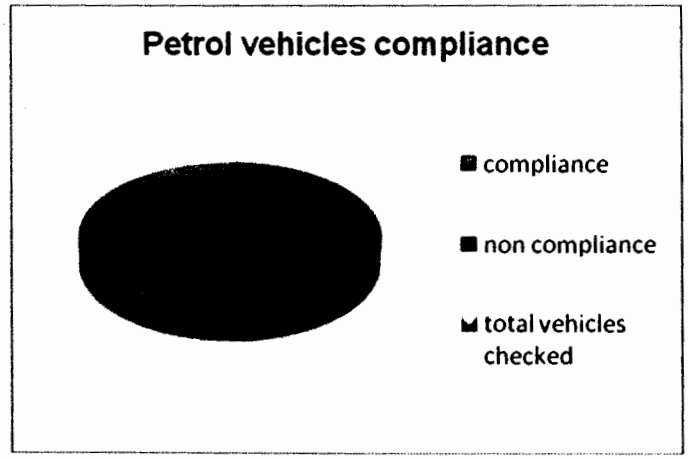

Figure 4.17.1 Shows petrol vehicles compliance in Muzaffarabad

CHAPTER 5

CONCLUSSION

Findings of study lead to the conclusion that proper management of air quality in context of vehicular emissions requires a balance between establishment of standards and policy making. According to results of the study, 88.1 percent of vehicles use diesel, 5.4 percent use Petrol and 6.5 percent of vehicles use CNG as a fuel in Islamabad. While in Muzaffarabad, 87.6 percent of vehicles use diesel and only 12.4 percent vehicles use petrol as a fuel. Hence, diesel is most frequent type of fuel being used in both cities.

Out of total vehicles (2503) studied in Islamabad, 2002 (80%) were in compliance to standards while 500 (20%) vehicles were not observing the standards. While in Muzaffrarabad 58 percent of vehicles studied were not in compliance to standards, and 42 percent vehicles were in complaince. Hence, level of compliance is much more in Islamabad as compared to Muzaffarabad mainly due to the fact that in Islamabad, there are strict implementations of regulations regarding vehicular emissions by the concerned authority.

As regards the opacity measurements of diesel vehicles in Islamabad out, of total diesel vehicles studied (2205), maximum number of vehicles had opacity within class interval of 11-20 that is 869 vehicles and 488 vehicles have opacity within interval of 1-10, Hence one thousand and twenty five (82%) vehicles have opacity under the permissible limits and four hundred and eighty (17.7%) vehicles were not observing the limits. In

Muzaffarabad, 423 diesel vehicles were checked for opacity, highest number of vehicles have opacity in interval of 11-20 which is 65 in number. Two hundred and twenty nine (54%) vehicles have opacity under the permissible limit and one hundred and ninety four (46%) vehicles were not observing the limits, hence it is obvious from comparative analysis of vehicles compliance of both cities, level of compliance in diesel vehicles is more in Islamabad as compared to Muzzaffarabad.

Petrol vehicles studied in Islamabad and Muzaffarabad were tested for HC and CO emissions. In Islamabad highest number of petrol vehicles (78) tested for HC emission was in class interval of 0.00-200 (ppm) which are in compliance to 1993 amended vehicular emissions of Pak EPA (450ppm). In Islamabad, Out of total petrol vehicles studied for hydrocarbon level (136), one hundred and eighteen (118) vehicles have hydrocarbon level under the permissible limit and eighteen (18) vehicles were not following the limits. While in Muzaffarabad, maximum vehicles (28) had HC emissions in interval between 0.00-500pm which relatively high from the standard value (450 ppm). Petrol vehicles studied for HC level were 60, out of which twenty six (26) vehicles have HC level under the permissible limit and thirty four (34) vehicles were not in compliance. Hence HC emission level is more in Muzaffarabad as compared to Islamabad.

In Islamabad petrol vehicles studied for CO level, highest number of vehicles (90) fall in interval between 0.00-0.99(%) followed by 35 vehicles in interval between 2.00-2.99 (%) and a very low number of petrol vehicles fall among other intervals of CO. Compliance level of Petrol vehicles in Islamabad is 97.5%. While in Muzaffarabd, CO emissions of petrol vehicles highest number of vehicles had emission level between 0.00-0.99. Level of compliance in petrol vehicles in Muzaffarabad is 81.7%.Hence CO emission level

recorded in petrol vehicles was more in Muzaffarabad as compared to Islamabad mainly because of strict implementation of regulations in Islamabad.

In Islamabad, CNG vehicles were also tested for HC and CO level. In case of HC, out of 163 CNG vehicles studied, large number of vehicles fall in limits between 0.00-500ppm and in other intervals of HC emissions trace amount of CNG vehicles were present. Hence compliance level of CNG vehicles for HC level was 95.7%. While in Muzaffarabad out of total vehicles studied (163) 97 and 55 CNG vehicles were within interval of 0.00-0.99 and 2.00-2.99 respectively. While in other intervals, small numbers of vehicles were present. Compliance percentage of CNG vehicles for CO was 97.5%, hence level of compliance of CNG vehicles was higher for CO emissions.

Regarding vehicles frequency in Muzaffarabad, 19 buses (3.9%), 100 Trucks (20.7%), 170 Vans (35.2%), 5 Shehzores (1%), 80 Cars (16.6%), 79 Jeeps (16.4%), 25 Suzukis (5.2%), 1 Tractors (0.2%), and 4 Rickshaws (0.8%) were there. Hence, maximum portion of transport in Muzaffarabad was consisted of vans. Truck and jeeps also contributed significant portion of transport sector.

Study findings can be summarized as follow;

- Diesel – most frequent type of fuel being used.
- Level of compliance - much more in Islamabad.
- Level of opacity in diesel vehicles - is more in Muzzaffarabad.
- In Islamabad, 43 % petrol vehicles While in Muzaffarabad 82% of petrol vehicles had HC emission level under the permissible limit.
- In Islamabad, 97.5% petrol vehicles While in Muzaffarabad 81.7% of petrol vehicles had CO emission level under the permissible limit.

- In Islamabad compliance percentage of CNG vehicles for CO was 97.5%, while compliance level of CNG vehicles for HC level was 95.7%.
- Maximum portion of transport in Muzaffarabad was consisted of vans, Truck and jeeps.

Recommendations

- As it is very much evident from findings of study that major portion of vehicles in both cities consume diesel as fuel. And diesel vehicles emit particulate matter as residual, which deteriorate air quality and is very harmful to humans especially with respiratory diseases. Hence, to reduce PM level in air ministry should make it necessary for diesel vehicles to be installed with particle filters.
- It is also clear from study that level of compliance in city other than capital is very much low. Hence there should be strict implementation of rules all over Pakistan including the Northern areas especially Muzafarabad. There must be strong coordination between transport sector and Pak EPA for proper implementation of standards.
- Levels of emissions in both cities are more and to reduce these hazardous emissions, new technology needs to be introduced like Exhaust Gas Recirculation. It involves returning of Emissions back to Fuel inlet, which helps in reduction of gas emissions. And to reduce No_x concentration in air Catalytic converter can be installed in the vehicles.

- Pakistan largely depends on Oil for fulfillment of energy needs in transport section (Sindhu 2008). To meet increasing demand of oil Pakistan Spent 5.23 billion dollar on oil import (Economic Survey of Pakistan 2006-2007). There is urgent need for effective Energy Planning for proper placement of social and economic services.
- Air is common resource and every human being is directly related to it. For this reason, Public and Private Partnership are essential. Such partnership can help to improve and revise quality, quantity and fares of public transport.
- Clean and healthy air is basic human right. In this regard, production and development of cleaner fuel is need of hour. So that hazardous emissions can be cut down to significant level.
- While assessing risks of environmental issues, agency must widen its area of concern to environmental impacts in perspective of Public Health.
- Another way to reduce emissions is to encourage use of bicycles and discourage private vehicles by providing efficient and affordable transport system in the country.

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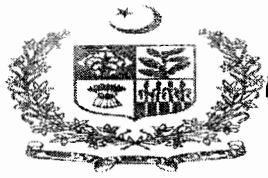
Annexure 1

The Gazette  *Pakistan*

EXTRAORDINARY

PUBLISHED BY AUTHORITY

ISLAMABAD, _____ 2008

PART II

Statutory Notifications (S.R.O)
GOVERNMENT OF PAKISTAN
MINISTRY OF ENVIRONMENT
NOTIFICATION
Islamabad, the_____, 2008

S.R.O. _____. In exercise of the powers conferred under clause (c) of sub-section (1) of section 6 of the Pakistan Environmental Protection Act, 1997 (XXXIV of 1997), the Pakistan Environmental Protection Agency, in anticipation of approval of the Pakistan Environmental Protection Council, is pleased to direct that the following further amendments shall be made in its Notification No. S.R.O.742 (I)/93, dated the 24th August, 1993, namely:

In the aforesaid Notification, in paragraph 2._____

(1) Annex-III shall be replaced with the following Annex-III (amended):-

Annex-III (Amended)

NATIONAL ENVIRONMENTAL QUALITY STANDARDS FOR MOTOR VEHICLE EXHAUST AND NOISE

(i) For Inuse Vehicles

S. No.	Parameter	Standards (maximum permissible limit)	Measuring method	Applicability
1.	2.	3.	4.	5.
1.	Smoke	40% or 2 on the Ringlemann Scale during engine acceleration mode.	To be compared with Ringlemann Chart at a distance of 6 meters or more	Immediate effect
2.	Carbon Monoxide	6%	Under idling conditions: Non-dispersive infrared detection through gas analyzer.	
3.	Noise	85 db (A).	Sound – meter at 7.5 meters from the source.	

(ii). For New Vehicles

EMISSION STANDARDS FOR DIESEL VEHICLES

(a). For Passenger Cars and Light Commercial Vehicles (g/Km)

Type of Vehicle	Category / Class	Tiers	CO	HC+NOx	PM	Measuring Method	Applicability
1.	2.	3.	4.	5.	6.	7.	8.
Passenger Cars	M 1: With reference mass (RW) upto 2500 kg. Cars with RW over 2500 kg to meet N1 category standards.	Pak-II, IDI	1.0	0.7	0.08	NEDC (ECE 15 + EUDCL)	i. All imported and local manufactured diesel vehicles w.e.f. 01-07-2012.
		Pak-II DI	1.0	0.9	0.10		
Light Commercial Vehicles	N1-I (RW < 1250 kg)	Pak-II, IDI	1.0	0.70	0.08		
		Pak-II, DI	1.0	0.90	0.10		
	N1-II (1250 kg < RW < 1700 kg)	Pak-II, IDI	1.25	1.0	0.12		
		Pak-II, DI	1.25	1.3	0.14		
	N1-III (RW >	Pak-II,	1.50	1.2	0.17		

1700 kg)	IDI				
	Pak-II, DI	1.50	1.6	0.20	

Parameter	**Standards (maximum permissible limit)**	**Measuring method**
Noise	85 db (A)	Sound - meter at 7.5 meters from the source.

(b). For Heavy Duty Diesel Engines and Large Goods Vehicles (g/Kwh)

Type of Vehicle	**Category / Class**	**Tiers**	**CO**	**HC**	**NOx**	**PM**	**Measuring Method**	**Applicability**
1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**
Heavy Duty Diesel Engines	Trucks and Buses	Pak-II	4.0	1.1	7.0	0.15	ECE R-49	local manufactured vehicles w.e.f. 01-07-2012.
Large goods diesel vehicles	N2 (2000 and up)	Pak-II	4.0	7.0	1.10	0.15	EDC	

Parameter	**Standards (maximum permissible limit)**	**Measuring method**
Noise	85 db (A)	Sound - meter at 7.5 meters from the source.

EMISSION STANDARDS FOR PETROL VEHICLES (g/km)

Type of Vehicle	**Category / Class**	**Tiers**	**CO**	**HC+NOx**	**Measuring Method**	**Applicability**
1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**
Passenger Cars	M 1: With reference mass (RW) upto 2500 kg. Cars with RW over 2500 kg to meet category standards.	Pak-II	2.20	0.5	NEDC (ECE 15 N1+ EUDCL)	All imported and new models locally manufactured petrol vehicles w.e.f. ** 1st July, 2009
Light Commercial Vehicles	N1-I (RW < 1250 kg)	Pak-II	2.20	0.5		
	N1-II (1250 kg < RW < 1700 kg)	Pak-II	4.0	0.65		
	N1-III (RW > 1700 kg)	Pak-II	5.0	0.8		
Motor Rickshaws & Motor Cycles	2, 4 strokes < 150 cc	Pak-II	5.5	1.5	ECE R 40	
	2, 4 strokes > 150 cc	Pak-II	5.5	1.3		

Parameter	**Standards (maximum permissible limit)**	**Measuring method**
Noise	85 db (A)	Sound - meter at 7.5 meters from the source.

Explanations:

DI: Direct Injection.
IDI: Indirect Injection.
EUDCL: Extra Urban Driving Cycle.
NEDC: New European Driving Cycle.
ECE: Urban Driving Cycle.
M: Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.
N: Motor vehicles with at least four wheels designed and constructed for the carriage of goods.

*

New model means both model and engine type change.

**

The existing models of petrol driven vehicles locally manufactured will immediately switch over to Euro-II emission standards but not later than 30th June 2012.