VEHICULAR EMISSIONS MONITORING IN SELECTED AREAS OF ISLAMABAD, PAKISTAN

By

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ABSTRACT

Present study was conducted to assess the air pollution level caused by vehicular emissions in the selected areas of capital city Islamabad. Four hundred eighty (480) vehicles based on fuel types (Petrol, CNG and Diesel) were tested in collaboration of Islamabad Traffic Police (ITP) and Pakistan Environmental Protection Agency (Pak-EPA) for four main toxic pollutants i.e., CO, NOx, CO_2 and Hydrocarbons at eight various locations within the Islamabad city. Opacity was analyzed for diesel vehicles, the measured values of these parameters are compared with NEQS. Highest Hydrocarbons (HC) are emitting from CNG fuel (i.e., 1818 ppm/vehicle) following petrol with (311ppm/vehicle) value. Petrol is emitting highest CO with 2.3% by vol. per vehicle. Diesel vehicles were found with highest NOx emissions as 320 ppm/vehicle. Smoke opacity was tested 160 (One hundred sixty) from diesel vehicles out of which 53 exceeds the NEQS limit (40 HSU). The results from data analysis indicate that current situation of vehicular emission in Islamabad is highly unsatisfactory and there is a need to form strategies which could later be adopted at a national level. Fuel quality, traffic congestion, vehicles poor maintenance etc were the found responsible factors. This work shall be helpful in developing awareness about existing air quality awareness in Islamabad among the stakeholders like public, environment protection agencies, local governments & traffic police; it will help concerned corners in fine tuning current activities to control this menace, their impact on air quality and to reduce air pollution in the major cities of Pakistan.

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All kinds of praises and thanks are for Almighty Allah, who always guides us from darkness to light and to Whom I best owe the potential and ability to make material contribution in already existing oceans of knowledge. Special praises, for His last Prophet Hazrat Muhammad (P.B.U.H) who is the forever-luminous torch of knowledge and guidance for humanity.

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No word of acknowledgement can be adequate for the love and benevolent cooperation of my parents and my family whose heartbeats with golden sentiments for me and their hands always raise in prayers for my success. Their love has served me as a beacon of light, and I owe everything to them.

Imtiaz Hussain

ABBREVIATIONS

VOCs	Volatile Organic Compounds
NDIR	Non -Dispersive Infrared
NH & MP	National Highway and Motorway Police
CNG	Compressed Natural Gas
LPG	Liquid Petroleum Gas
NMVOC	Non-Methylated Volatile Organic Compounds
JICA	Japan International Corporation Agency
ICT	Islamabad Capital Territory
$\mu g/m^3$	Microgram Per Cubic Meter
PM	Particulate Matter
NEQS	National Environmental Quality Standards
AQI	Air Quality Index
PAMA	Pakistan Automotive Manufactures Association
MVE	Motor Vehicle Examiners
WHO	World Health Organization
EPA	Environmental Protection Agency
PAHs	Polycyclic Aromatic Hydrocarbons
SO_2	Sulfur Dioxide
NO	Nitric Oxide
Pb	Lead
CO	Carbon Monoxide
O_3	Ozone
ARAI	Automotive Research Association of India
ETO	Excise and Taxation Office
M-1	Motorway
DNA	Deoxyribose-Nucleic Acid
IDC	Indian Driving Cycle
EU	European Union

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CHAPTER 1
INTRODUCTION

1.1 Study background

With the growth in global population and relevant human demands, vehicular traffic has also increased rapidly and has threatened the environment of urban areas. Nowadays, vehicular emissions have become the paramount cause of primary air pollution and have deteriorated the air quality. (Pandian et al., 2009; He et al., 2002; Mayer, 1999). According to a report, in the year 2000 number of vehicles have grown to 700 million globally. Namely, massive vehicular population growth has intensified the global air quality crisis, i.e. 40 – 80% of air pollution in cities is attributed to the emissions from the automobiles. Pollution from vehicular Volatile Organic Compounds (VOCs) has been observed to pose more serious threats to the developing countries as compared to the developed world i.e. United States and Europe. The comparison is demonstrated by the VOCs data from Pakistan, Egypt, India and Thailand (Kamal et al., 2012; Arayasiri et al, 2010; Chan and Yao, 2008).

The advancements in technology are yet unable to counteract the growth in vehicular pollution. Therefore, it is projected that air quality might show further decline in the cities in future. This congruence clearly depicts the direct relation between the air pollution and vehicular emissions i.e. Carbon monoxide (CO), Ozone (O_3) and particulate matter (Davis, 1998).

The vehicular emissions also contribute to the public health impacts (Utell et al., 1998). Automobiles release particulate matters including sub-micron particles (PM_{10}). These microparticles are reported to be directly associated with the high mortality rates (Anon, 1995), suggesting their important role in contaminating air. Vehicular exhausts and relevant industrial facilities also liberate NO_2, which produces ozone (O_3), by photochemical reaction, that influences allergic asthmatics by reinforcing allergic responses. Likewise, Sulfur dioxide (SO_2), Nitric oxide (NO), acidic aerosols and particulates effects pulmonary tract and may cause bronchial mucous inflammation (Karen and Michak, 1991). Moreover, several studies manifest the crucial part the air pollution play in producing and escalating allergic disorders and it is often referred as a disease of civilized society (Bonai et al., 1994).

To evaluate vehicular emission pollution and related environmental and health impacts, a survey has been carried out at an Indian megacity which quantified the air pollution and its vulnerability index at traffic intersections. The United Nations have also reported that more than 600 million individuals in cities globally are exposed to threatening levels of air pollution generated by automobile traffic (Cacciola et al., 2002).

The risk of air pollution and its effects is currently drawing much attention of environmental health advocates, environmental regulatory agencies, industrial facilities and public. It is accepted worldwide that air quality, outdoor as well as indoor, is associated with the defects and deaths from pulmonary and cardiovascular disorders (Ibrahim et al., 2012).

1.2 Emissions from a vehicle

Vehicles ae powered by the combustion of various fuels in their engines. The evaporation of fuel along with the combustion process release exhaust gases to the environment which pollute the air. The exhaust gases and emissions due to evaporative losses are the key pollutants from automobiles as illustrated in the figure.

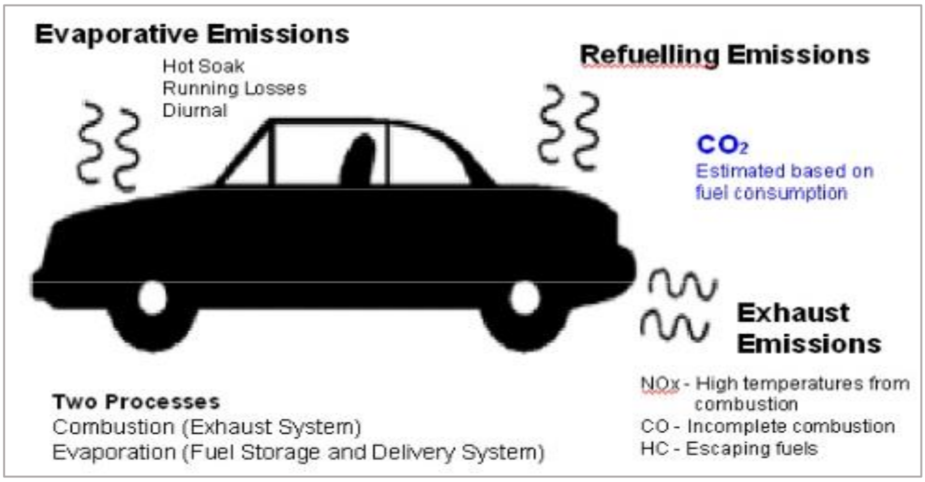


Figure 1.1 Vehicular Emissions (Source www.fraqmd.org/autoemissions.html

The fuels that power a vehicle is generally composed of hydrocarbons i.e. compounds consisting of carbon and hydrogen elements. In an ideal condition, when a fuel is burnt oxygen combines with hydrogen and converts it into water, whereas carbon will be transformed into carbon dioxide (CO_2). There would be no effect on the aerial nitrogen, and the atmospheric balance will remain unchanged. Nevertheless, the fuel combustion is never ideal, and in real scenario vehicular engines emit several types of pollutants. They usually include oxides of nitrogen (NO, NO_2), carbon (CO, CO_2), sulfur (SO_2) and oxygen.

The most prevalent air contaminants that attracts concern of environmentalists and regulatory bodies are particulate matter, sulfur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), lead (Pb), polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) (Rekhadevi et al., 2010). However, ozone (O_3) is regarded as a secondary pollutant in addition to lead and sulfur dioxide, as they receive comparatively little concerns (Han and Naeher, 2006).

1.2.1 Exhaust Pollutants

i. Hydrocarbon (HC)

Hydrocarbons are released into the atmosphere when fuel in the engine, either do not burn or undergoes incomplete combustion. These hydrocarbons transform into tropospheric ozone when reacts with nitrogen dioxide in the presence of sunlight. Ozone is a significant constituent of smog. Ozone is also responsible for public health implications such as eye irritation, lungs disorders and diseases pulmonary system. Several other hydrocarbons are also hazardous in themselves and may cause cancer. Therefore, the hydrocarbon emission is subject of serious concern as an urban air pollutant (Milt et al., 2003).

ii. Oxides of Nitrogen (NO_X)

Nitrogen and oxygen in the atmosphere react under elevated temperature and pressure in the vehicular engine and forms different oxides of nitrogen, commonly referred as NOx. These oxides of nitrogen, like hydrocarbons, participates in the production of ozone (O_3). They are also responsible for the acid rain formation (Nazarenko et al., 2017).

iii. Carbon monoxide (CO)

When fuel undergoes combustion in vehicular engine, carbon is oxidized in the presence of air and transforms into carbon dioxide and carbon monoxide. Carbon monoxide (CO) is the result of partial burning and incomplete oxidation. As a pollutant, it is highly toxic gas as it replaces the oxygen in the blood and affects the optimum blood flow conditions. The situation is especially alarming for individuals with the cardiovascular disorders (Tsai et al., 2017).

iv. Carbon Dioxide (CO_2)

Carbon dioxide is a product of ideal combustion process. Nevertheless, contemporarily it is regarded as a matter of serious pollution concern by the U.S. Environmental Protection Agency (EPA). Carbon dioxide (CO_2) does not directly influences the public health. It is one of greenhouse gases and produces greenhouse effect leading to global warming (Verner and Sejkorova, 2018).

1.2.2 Evaporative Emissions

Air pollution is also caused by the contaminants that escape into the atmosphere due to the evaporation of fuels. With the advanced and efficient vehicular exhaust systems and effective gasoline formulae, losses of pollutants to air due to evaporation is more than due to combustion in engines. Evaporative losses are maximum during the hot season and day time, when level of ozone is also highest.

1.3 Factors affecting the vehicular emissions

The problem of traffic emissions increases with disturbed flow and delays particularly at traffic intersections and junctions or signals stops. It results in idle flow rate, vehicles queuing and cruise driving modes. All these characteristic related to traffic and road etc. raising the emissions as identified by Pandian et al., 2009, as ‘the type, size, age of a vehicle, and condition of its engine, type and condition of emission control equipment, engine characteristics, vehicle maintenance, and weight, all correlate to the emissions’. The functioning of emission control equipment/devices are also affected by engine size (Beydoun, 2004). The quality of the fuel used also have an unswerving effect on the exhaust emission (Perry and Gee, 1995). Pandian et al., 2009 also described the different characteristics of traffic, road and vehicles as factors responsible for producing the vehicular emissions.

Table1.1. Traffic, road, and vehicle characteristics in relation to the emissions at traffic intersections

(Source: Pandian et al., 2009)

Source	**Attributes**	**Impact on Emissions**
Traffic	*Traffic-flow rate*	More vehicle flow than the capacity of road leads to the congestion and in turn affects driving pattern and there by increases the emissions.
	Fleet speed	Correlated with traffic density as well traffic-flow rate, and affects the emissions
	Queue length	Measures of effectiveness of signal controls
	Driving mode	Rapid acceleration and deceleration emit more emission than cruising followed by idle driving mode
	Vehicle mix (traffic fleet)	Cars contribute more to CO emissions whereas heavy-duty vehicles emit more PM, while two-wheelers contribute to HC and NOx emissions
	Traffic density	More density increases the mean residence time of the vehicles on the road causing higher pollutant concentrations
Road	*Type of road*	Larger type streets help reducing congestion and density so emit lesser pollutants compared to the smaller ones
	Type of intersection	Roundabout intersections are subject to lesser emissions than other intersections
	Speed hump	Helps to reduce the speed of vehicles in optimum range to emit lesser pollutants
	Driving style	Aggressive driving style generates more emissions and is less economical in fuel consumption
Vehicle	*Type of vehicle*	Heavy-duty vehicles emit more NOx and PM compared to light duty vehicles, which are responsible for more CO and HC emissions
	Age of vehicle	Has positive effect on emissions
	Engine capacity	Has negative effect on CO emissions
	Mileage	Has positive effect on emissions

	Emission control equipment	Has negative effect on emissions
	Ambient temperature	Lesser ambient temp will have effect on ignition temp as well cooling down the vehicle rapidly from hot mode to cold mode which enhances the emission
	Engine load	Mainly increases the fuel consumption and emissions of NOx
	Vehicle weight and size	Increased fuel consumption and emissions of PM and NOx
	Maintenance	Frequent maintenance helps to reduce emission and delays the vehicle deterioration

1.4 Air Quality of Pakistan

Pakistan is striving to fight climate change. It's a challenge to combat the issue due to least institutional capacity and lack of direction. Pakistan's major urban areas are polluted to the same extent as world's highly polluted areas as per WHO reports. It is estimated that 60 $\mu g/m^3$ (microgram per cubic meter) of $PM_{2.5}$ particulates are present in the air of Pakistan. The value is four-folds the permissible levels recommended by the National Environmental Quality Standards (NEQS) for Ambient Air by Pakistan Environmental Protection Agency (PK-EPA). The deteriorated quality of air may pose serious threats to human health, augmenting respiratory and cardiovascular disorders among the masses. It is reported that 59,241 mortalities are attributed to the air pollution every year in Pakistan (WHO, 2016). Major cities of Pakistan are highly polluted as per WHO 2016 Global Urban Ambient Air Pollution database.

Key findings for PM_{10} concentrations of the report are tabulized in table 1.2.

Table 1.2: Air Quality of mega global cities

Data source: Global Urban Ambient Air Pollution Database 2016

S.no	Cities	PM_{10} conc.(μg/m^3)
1	Peshawar	111
2	Rawalpindi	107
3	Karachi	88
4	Lahore	68
5	Islamabad	66
6	Dehli	122
7	Beijing	851
8	Paris	18
9	London	15
10	Pak-EPA limit	15
11	WHO limit	10

The concentration of PM_{10} in the cities of Pakistan is 6 to 10 times higher than the recommended values. Whereas, vehicular emissions are the major cause of pollution among many other pollution sources.

1.5 Vehicular Emissions Scenario in Pakistan

Over the past few years, the automobile industry in Pakistan has expanded with the considerable increase in per capita income. The road density and the registration count per year of vehicles in the cities has also increased with time. Since last 20 years, the estimated number of automobiles has raised from about 3 million to around 15 million in 2018. It has aggravated the air pollution problems in the area. Karachi, Peshawar and Islamabad also have poor Air Quality Index (AQI) (Business Recorder, October 2018). According to Pakistan Automotive Manufactures Association (PAMA), as published in Dawn News: “There are no standards evolved for the automobile produced in Pakistan nor are there any labs to check the standards of safety etc.” (Shirwani et al., 2019).

1.6 Legal Framework

Pakistan Environmental Protection Act 1997 has addressed vehicular air pollution under section 15, and in the National Environmental Quality Standards. Nevertheless, the institutional arrangement and required regulations have not been made to execute this act and NEQs. Nowadays, it is mandatory to get commercial automobiles examined by MVE (Motor Vehicle Examiners) regularly. The capacity and obligations of MVEs are defined by Motor and vehicular Authority (MVA,2006).

1.7 European Standards for Vehicular Emissions

Table 1.3. European Standards for Vehicular Emissions

Standards	**Applied to new passenger cars approvals from**	**Applied to new registrations from**	**Emissions standards (petrol)**	**Emissions standards (diesel)**
Euro 1	1 July 1992	31 Dec 1992	CO: 2.72g/km HC + NOx: 0.97g/km	CO: 2.72g/km HC + NOx: 0.97g/km PM: 0.14g/km
Euro 2	1 July 1996	1 January 1997	CO: 2.2g/km HC + NOx: 0.5g/km	CO: 1.0g/km HC + NOx: 0.7g/km, PM: 0.08g/km
Euro 3	1 January 2000	1 January 2001	CO: 2.3g/km THC: 0.20g/km NOx: 0.15g/km	CO: 0.66g/km HC + NOx: 0.56g/km NOx: 0.50g/km, PM: 0.05g/km
Euro 4	1 January 2005	1 January 2006	CO: 1.0g/km THC: 0.10g/km NOx: 0.08g/km	CO: 0.50g/km HC + NOx: 0.30g/km NOx: 0.25g/km PM: 0.025g/km
Euro 5	1 September 2009	1 January 2011	CO: 1.0g/km THC: 0.10g/km NMHC:0.068g/km NOx: 0.06g/km PM: 0.005g/km	CO: 0.50g/km HC + NOx:0.23g/km NOx: 0.18g/km PM: 0.005g/km

Euro 6	1 September 2014	1 September 2015	CO: 1.0g/km THC: 0.10g/km NMHC: 0.068g/km. NOx: 0.06g/km PM:0.005g/km (direct injection only)	CO: 0.50g/km HC + NOx: 0.17g/km NOx: 0.08g/km PM: 0.005g/km

1.8 Vehicular Emission Monitoring System

European Union (EU), Automotive Research Association of India (ARAI) and United States Environmental Protection Agency (US-EPA) have developed standards for vehicular exhaust emissions to control air pollution (ARAI, 2016). These standards were devised after experimentation and various tests carried on in the chassis dynamometer studies. Number of regulatory bodies use emission models (i.e., COPERT, PHEM, EMFAC, and MOVES) to estimate emissions as devise control strategies (Sturm et al., 2005). Mostly dynamometer is used to emissions estimation at the controlled laboratory scale based on different driving cycles. The results are further supplemented into the depression models to predict the urban air quality. In this way ,it is used to make the policies(Hagemann et al., 2004).

Remote Sensing, Car Chaser Technique, Road Tunnel studies and on-board monitoring in the probe vehicle (Corsmeier et al., 2005) are also used to estimate emissions in the real-world scenario. Road tunnel studies were reported with some limitation of under prediction (Pierson et al., 1996; Hickman and Geller, 2005). Across Road Studies were also carried out using Remote Sensing that involves optical measurement devices with UV and IR sensors for emissions monitoring (Jimenez 1999). It have more applications like reliability checking of the control strategies and screening off the vehicles for higher emission values by the law and enforcement works (Williams et al., 2003).

In the running conditions of data collection, now there are different sophisticate instrumentations i.e., portable emission monitoring systems (PEMS)(Frey and Unal, 2002). The results from the PEMS are evaluated on different traffic attributes such as road geometry, signalization, type of traffic flow etc (Zhai et al., 2008). On-board emission measurements are also implemented by the EU Regulatory Design of command and control (EU CAS) on the rea time scenarios (Skeete, 2017).

1.9 Health Impacts of Vehicular Emissions

Vehicle exhaust emissions being the potent air pollutants are causing adverse health effects (directly and indirectly) as their by-product gases and particles have effects on, cardiovascular disease, respiratory disease, mortality, fetal development etc. (Table 1.4). It can be reduced by some mitigation like controlling fuel composition and the design and function of vehicle engines.

Table 1.4: Health Implications of Vehicular Emissions
`Source: Vehicular Exhausts, M Burr and C Gregory, Cardiff University, Cardiff, UK and 2011 Elsevier B.V.

Health implications	Causative Emissions	Possible phenomena
Acute Toxic	Carbon Monoxide (CO)	Binding to hemoglobin and myoglobin, brain injury
Chronic Toxic Developmental	Pb, Co, PAHs	Neurological, hemopoietic, & renal damage, DNA damage
Nasal, Optic	Particulates, VOCs	Irritation & inflammation
Acute respiratory	$PM_{2.5}$, O_3, NO_2	Aggravate allergies, pulmonary damage
Chronic respiratory	$PM_{2.5}$, diesel particles	Inflammation, oxidative damage
Acute cardiovascular	$PM_{2.5}$ Diesel particles CO PAHs	Red cell sequestration, increased blood viscosity, poor heart involuntary control, Arrhythmias, ischemia
Chronic Cardiovascular	Particulates	Same as acute effects
Acute Mortality	Particles, O_3, NO_2	Cardiovascular and respiratory disorders
Cancer	Diesel particles, benzene, PAHs, 1,2-butadiene, O_3	DNA damage

1.10 Present Study Description

Present study was conducted in Islamabad(capital), Pakistan. The territory is bounded by Punjab and Khyber Pakhtunkhwa provinces which covers 906 km^2 (349.8 mi^2) area. This study is designed to monitor the pollution coming from the heavy load of traffic in the Islamabad in selected heavily Traffic areas. Its population is 2851868HH in federal district and 209180HH as urban side (PBS, 2017 census).

All major cities and towns are linked to Islamabad through a network of motorways like M-2 Motorway (228 mi) and connect Islamabad and Lahore and M-1 Motorway that connects Islamabad with Peshawar (96 mi). Islamabad is linked to Rawalpindi through the Faizabad Interchange, which has a daily traffic volume of about 48,000 vehicles as reported by NHA(ITP,2019).

Over the years, in the capital city, Islamabad, the vehicular mass has gone up extremely high due to city extension and population growth and industrial activities. Consequently, now facing the menace of a variety of air pollutants stemming from other sources as well as from the vehicular traffic (Shah et al., 2006).

The Excise and Taxation Office (ETO) Islamabad have registered almost 0.7 million vehicles till to date. Different convenient schemes offered by banks etc. had caused significant increase in number of vehicles in the city during past years. 6,000 vehicles per month and 200 cases per day (i.e., 50 to 70 motorbikes, 90 to 100 private cars, four to five commercial vehicles and 10 to 15 government vehicles Nespak, 2016). So, it is important to assess/monitor the emissions for getting the baseline for better policy and management.

Different studies evidenced overburdened local atmosphere comprising of PMs and toxic trace metals (Shah et al., 2003). The city atmosphere is almost comparable to that of any global grossly polluted city (JICA, 2000).

Shah and Shaheen, 2003 reported higher atmospheric metals concentration (iron, zinc, manganese, lead, Cadmium and potassium) as compared to European urban sites due to anthropogenic sources (i.e., automobile emissions, industrial activities, combustion processes, and mineral dust). A comparative study presented high concentrations of airborne trace metal (Shah and Shaheen 2006). Overall situation is thus posing a potential health hazard to the local population.

1.11 Aims and Objectives

Keeping background of vehicular pollution and associated problems, this study was designed with following specific aims and objectives.

i. To assess the air pollution level caused by vehicular emissions in the selected areas of capital city Islamabad.

1.12 Literature Review

Similar studies at national and international scale were reported here after reviewing different literature with same background**.**

Table 1.5. Literature review

Reference	**Study description**	**Key findings**
Jaikumar et al., (2017)	On-road vehicular exhaust emission under heterogeneous traffic conditions were monitored.	• Vehicular emissions during idling and cruising were generally low compared to emissions during acceleration
Hao et al., (2006).	Reviewed the latest technologies and management strategies for controlling emissions over last 10 years	• 80.2% of the PM_{10} from vehicular tailpipes is $PM_{2.5}$ in Beijing, • Despite the rapid increase of the vehicle population by 60% between 1998 and 2003, total vehicular emissions have not increased due to vehicular emission control.
Lang et al., (2014)	On-road vehicular emission in China from 1999 to 2011 was estimated, based on the emission factors of vehicles with different emission standards calculated by the COPERT model.	• CO and NMVOC emissions sources are cars and motorcycle and for NOx, there are Heavy duty truck (HDT)

Carslaw, et al, (2005)	Hourly mean concentration data for nitrogen oxides (NO_X), nitrogen dioxide (NO_2) and ozone (O_3) have been used to derive a method for estimating the mean primary NO_2 fraction from vehicle exhausts in London	• A median primary NO2 fraction of 10.6% accounts for an average of 21% of the observed NO2 concentration at roadside sites.
Casquero et al., (2019	A trend analysis of pollutants involved in NO_2 processes was done for the period 2003–2014 in traffic sites from three Spanish cities (Barcelona, Madrid and Granada)	• Reduction of 78%, 56% and 16% on NOx emissions in Barcelona, Madrid and Granada were estimated to be necessary to comply with the NO_2 annual limit of 40 $\mu g\, m^{-3}$
Costagliola et al., (2015).	To assess emission levels of different technology vehicles and investigate the use of a particulate number measurement technique at the exhaust of very low-emitting vehicles.	• All three vehicles comply with their standard limits, except CO for CNG passenger car and NOx for diesel car.
Wang et al., (2010).	Multiyear inventories of vehicular emissions in Beijing, Shanghai and Guangzhou from 1995 through 2005 have been developed to study the vehicle emissions trends in China's mega cities during the past decade.	• Vehicular emissions of CO, HC, NO_x and PM_{10} have begun to slow their growth rates and perhaps even to decline in recent years due to the implementation of measures to control vehicular emissions in these cities • Passenger cars and large vehicles (including heavy duty trucks and buses contributed 70% and 80% of the vehicular NO_x and PM_{10}

Ghose et al., (2004).	Vulnerable analysis (VA) has been carried out to evaluate the air pollution stress at different locations	• Replacement of old vehicles, reformulating diesel fuel, introduction of liquid petroleum gas (LPG) and compressed natural gas (CNG), massive improvements in infrastructure and radical traffic management measures are among the actions that will need to be brought together to achieve this objective.
Lin et al., (2019).	Particulate matters (PM2.5) were characterized and quantified from a place impacted by diesel vehicles fueled with diesel in Kaohsiung City, Taiwan. Exhaust constituents include CO, NOx, PM2.5 and particle phase PAHs.	• Different diesel vehicles with different ages and mileages affect exhaust emissions. • PM2.5 concentration from diesel engine vehicles exhausts were 3880± to 16500 $\mu g/m^2$. • Lower cumulative mileage of b 20000km has the lowest CO and NOx emission factor. • Mileage ranged from 2001 to 30000 km had an increased CO and NOx emission factors
Angelo et al., (2018)	Exhaust emissions of a sample of light in-use-vehicles were measured. And Emission factors of NO, CO and CO_2 were calculated based on on-road measurements	• Low speed and fuel efficiency were found to be related to high CO emissions.
Nagpure, et al., (2016).	Exhaust emissions of gaseous, particulate matter and mobile source air toxics (MSATs), volatile organic compound (VOCs) and PM10 (particulate matter 10	• Private vehicles (two wheelers and cars) have increased by 2- to 18-times in 2020 over the 1991 levels. Two wheelers found to be dominating the emissions of carbon monoxide (CO, 29e51%),

	mm) from no exhaust vehicular sources, during the past (1991to 2011) and future (2011 to 2020) scenarios in Dehli, India.	hydrocarbons (HC, 45e73%), acetaldehyde (46e51%) and total poly aromatic hydrocarbons (PAHs, 37e42%). Conversely, private cars were found to be responsible for most of the carbon dioxide (CO2, 24e42%), 1,3-butadiene (72e89%), benzene (60e82%), formaldehyde (23e44%) and total aldehyde (27e52%) between 1991 and 2011.
Harrison et al., (1997)	Airborne particulate matter from Birmingham, U.K, Coimbra, Portugal Lahore, Pakistan were analyzed.	• Large differences between the cities in source contributions are seen in the case of PM_{10}/TSP, with soil dust estimated to contribute 62% of total suspended particulate matter in the atmosphere of Lahore but contributing much less in Birmingham and Coimbra where road traffic emissions comprise a substantial percentage of the total.
Smith et al., (1995).	Concentrations of polycyclic aromatic hydrocarbon (PAH) were measured in samples of soils, surface and road dusts and air from various locations in Birmingham (UK) and Lahore (Pakistan).	• PAH levels in soils from Lahore were considerably lower than those collected in Birmingham despite far higher atmospheric concentrations due to Pakistan's climate enhancing the effects of photo-oxidation and volatilization. A high correlation was found between PAHs in airborne particles and soils in Lahore.
Colbeck et al., (2011)	Journey time and roadside exposure to particulate matter	• The overall mean journey-time concentrations of PM10, PM2.5, PM1,

	and carbon monoxide along major roads of Lahore during November 2007 was assessed. Measurements of particulate mass and carbon monoxide were carried out continuously inside an air-conditioned vehicle, while commuting, and outside the vehicle at 36 different locations in the city.	PM10-2.5 and CO were 103 g/m_3, 50 g/m_3, 38 g/m_3, 53 g/m_3 and 8 ppm, respectively. At the roadside average PM10, PM2.5, PM1, PM10-2.5 and CO concentrations were 489 g/m^3, 91 g/m^3, 52 g/m^3, 397 g/m^3 and 4 ppm, respectively. • traffic congestion reflected high automobile exhaust emissions but also the resuspension of road dust.
PAK-EPA/JICA (2001)	Ambient air quality measured using mobile station for hourly concentrations of air pollutants from 7:00 to 24:00 hrs from April to May 2000.	• PM_{10} of all cities exceeded the WHO permissible limit. • SO_X, NO_X, CO concentrations were reported within the limit Islamabad results were reported as PM_{10} as 520µg/m^3, SO_2 as 28ppb, CO as 1.55ppm, NO_2 as 148 ppb and O_3 as 10ppb
Ilyas, S. Z. (2007)	The local, regional, and global impacts associated with air pollutant emissions from motor vehicle activity, and the technological, behavioral, and institutional factors was studied in Pakistan	Robust traffic policy and systems are highly recommended based on the current situations of the country.

CHAPTER 2

MATERIAL AND METHODS

2.1.Backdrop

Keeping in view the aims, objectives and scope of the study, following methodology was adopted to undertake the study.

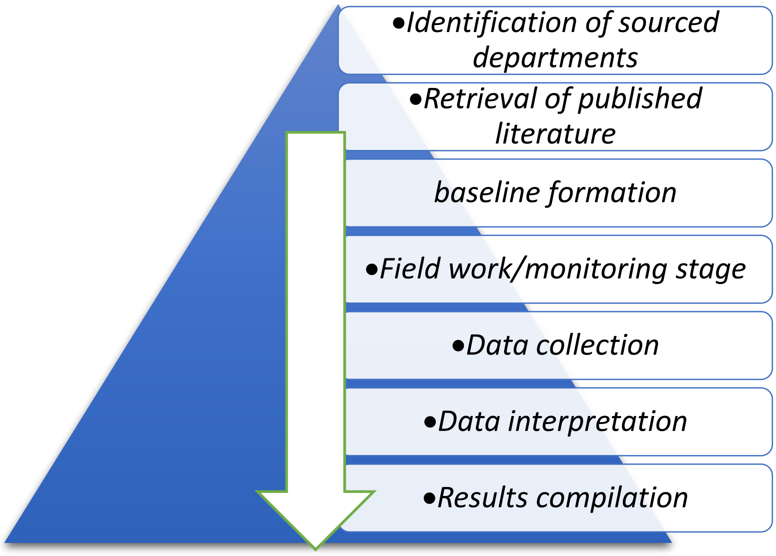


Figure.2. 3: Methodology layout

2.2. Sourced departments

To meet the scope of research, sourced departments and stakeholders were identified in the city that are directly or indirectly concerned with the environmental issues of the city as well as enforcement agencies etc. Pak -EPA and Islamabad Traffic Police were identified two such responsible bodies. Both were accessed after going through some documentation procedure.

Table 2.1: Details of sourced departments

Departments	**Description**	**Key role in present study**
PAK-EPA	The Pakistan Environmental Protection Agency, abbreviated as Pak-EPA), is an executive agency, Government of Pakistan managed by the Ministry of Climate change(MoCC). The agency is charged with protecting human health and the environment by writing and enforcing regulation based on laws passed by Parliament.	• Instrument provision • Laboratory access • Provision of technical assistance
ITP	ITP maintain smooth flow of traffic, prevention of accidents, helping road users in distress, ensuring rule of law through equal application, achieving the target of zero tolerance with firmness but politeness to gain the confidence and support of the community.	Field work
NTRC	National Transport Research Centre (NTRC) in the Planning and Development Division, as one of its Technical Sections, to provide much needed research and development (R&D) support for planning and appraisal of transport sector projects/plans in a coordinated and cost-effective manner. NTRC was transferred to the Communications Division in November 1992. It is effectively functioning as an R&D Wing of the Ministry of Communications.	Data collection

2.3. Published data Review

Various documents like published reports, research papers and newspapers articles were collected relevant to air pollution, air quality deterioration of Islamabad, and vehicular emissions etc. Different material was reviewed and reported. Reference of every citation is listed on chapter 6 of the References.

2.4. Baseline development

2.4.1. Sampling sites identification

Islamabad, the capital of Pakistan, is in the Potohar Plateau in the northwest of country. It is referred as Islamabad Capital Territory, though the area has historically been a part of the Punjab region and the North-West Frontier Province. It is located at 33°40′N 73°10′E and having population of 601,600 people. Eight location of Islamabad were selected based on traffic flux as shown in figure 2.2.

Table 2.2. Location of sampling points

Sampling point No.	Site	Code
1.	Faizabad	FZB 1
2.	Pirwadai	PRW 2
3.	Rawat T-cross	RWL/TC 3
4.	Turnol	TNL 4
5.	IJP road	IJP 5
6.	Express highway	EXP/HW 6
7.	Karachi company	KHI/CMP 7
8.	Barakau	BRK 8

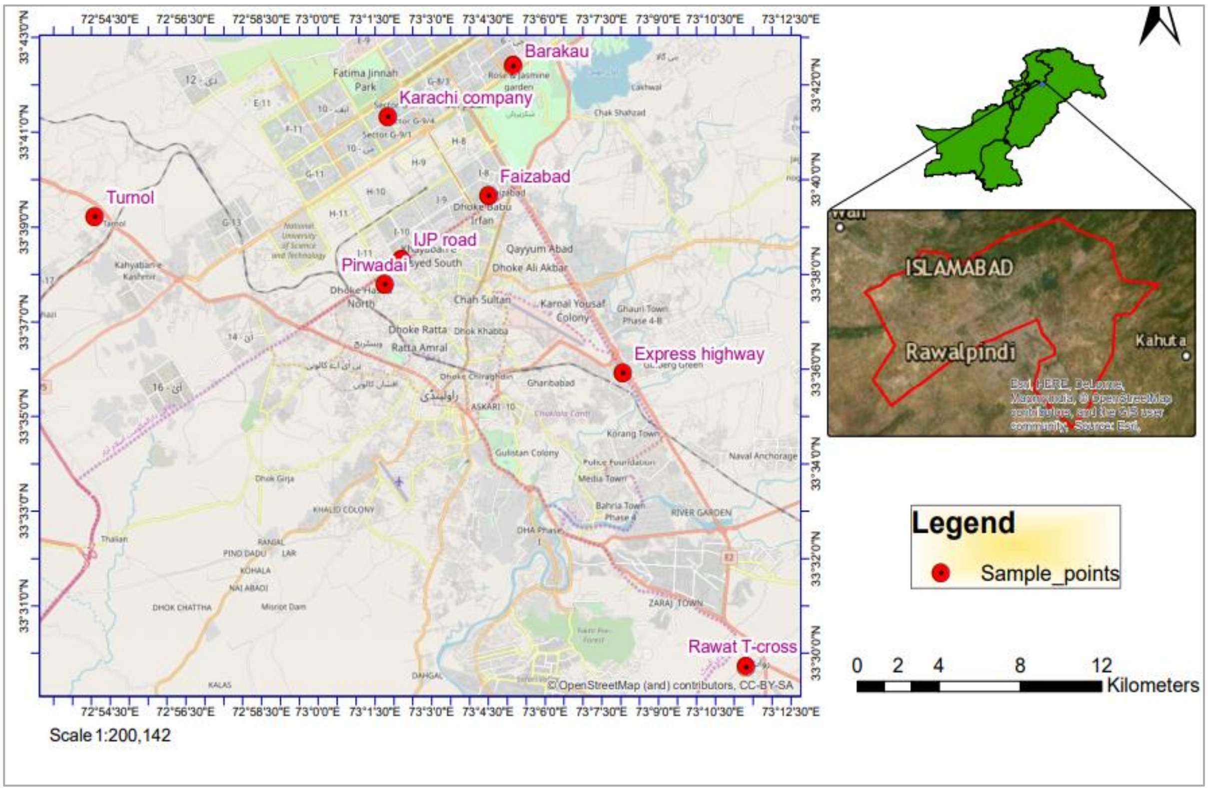


Figure 2.2: Sampling locations map

2.4.2. Vehicles tested

Vehicles were classified based on fuel type into three categories as;

- Petrol
- Diesel
- CNG

2.4.3. Number of vehicles tested

20 vehicles of each fuel type from eight location were monitored (20x3=60 vans in total). Cumulatively, 480 Vehicles were tested from eight different locations of Islamabad (60x8=480).

2.4.4 Analysis process

Vehicles were randomly chosen from roads with the help of traffic police officer. After getting permission of drivers, the gas sampling pump and detector tubes were used to detect gases in exhaust fumes (table 2.3).

2.4.5 Analysis time

Each analysis took approximately 10 minutes to completely analyze vehicle exhaust emissions. This time duration also included calibration of the instrument (Pak-EPA).

2.4.6 Information recorded

1. Vehicle type

2. Vehicle registration number

3. Model number

4. Fuel source

5. Exhaust gases emissions

2.4.7 Parameters tested

Pollutants that were analyzed for the study are included as;

ii. Hydrocarbons
iii. CO
iv. Carbon dioxide (CO2)
v. NO_X
vi. Opacity (Figure 2.4) Optical sensor (photodiode white LED) use to measure the radiated light with a defined intensity on to the blackening mark. The photodiode calculates the paper blackening base on the reflected light intensity. The more soot is deposited on the filter paper, the less light is reflected.

2.5 Reference Methods

Emissions /pollution monitoring was done based on the parameters recorded in table 2.3.

Table 2.3. Testing methods

S/No	Parameter	Analytical Technique/Method (US-EPA)
1.	Hydro-carbons	FGA 400 XDS Gas Analyzer Non -dispersive infrared NDIR
2.	CO	FGA 400 XDS Gas Analyzer Non -dispersive infrared NDIR
3.	CO_2	FGA 400 XDS Gas Analyzer Non -dispersive infrared NDIR
4.	O_2	Gas emissions analyzer Chemical Cell
5.	NO_X	Gas emissions analyzer Chemical Cell
6.	Opacity	Digital Smoke meter (WAGER Model: 6500)

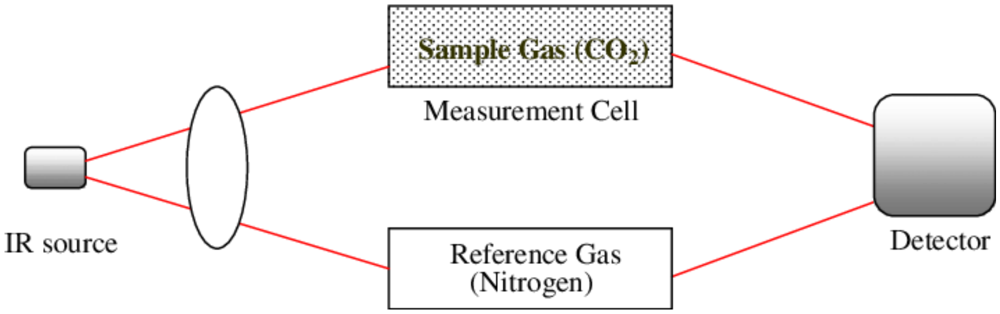


Figure.2.3a: NDIR working principle

Figure 2.3b: Gas emission Analyzer

Figure 2.4: Digital smoke meter

2.6 Emissions Standards Review

Different literature was reviewed to obtain the prevailing vehicular emissions standards for the said parameters. Pakistan has no such standards for emissions from vehicles. European standards for vehicles categories can be followed and compared as most feasible option to have clear picture. EURO standards define acceptable limits for exhaust emissions of new light duty vehicles sold in EU and EEA (European Economic Area) member states. The aim of Euro emissions standards is to reduce the levels of harmful exhaust emissions, chiefly Nitrogen oxides (NOx), Carbon monoxide (CO), Hydrocarbons (HC) and Particulate matter (PM). Euro 2 and euro 3 vehicles are common in Pakistan.

2.7 Field visit planning

Field visits were planned as shown in table 2.4 accompanied by traffic police staff and equipped with above mentioned instruments. Field visits were planned as follows;

Table 2.4: Sampling Execution planning

Day	Date	Location	Time	No. of vehicles tested
1.	05-03-2019	Point 1(Faizabad)	3 hrs	14
2.	06-03-2019	Point 1(Faizabad)	4 hrs	10
3.	07-03-2019	Point 1(Faizabad)	3 hrs	16
4.	10-03-2019	Point 1(Faizabad)	3 hrs	20
5.	12-03-2019	Point 2(Pirwadai)	4 hrs	12
6.	13-03-2019	Point 2(Pirwadai)	4 hrs	14
7.	14-03-2019	Point 2(Pirwadai)	4 hrs	18
8.	15-03-2019	Point 2(Pirwadai)	2 hrs	14
9.	16-03-2019	Point 2(Pirwadai)	3 hrs	18
10.	18-03-2019	Point 3(Rawat T-Cross)	3 hrs	12
11.	20-03-2019	Point 3(Rawat T-Cross)	2 hrs	12
12.	22-03-2019	Point 3(Rawat T-Cross)	3 hrs	12
13.	24-03-2019	Point 3(Rawat T-Cross)	4 hrs	12
14.	25-03-2019	Point 3(Rawat T-Cross)	4 hrs	12
15.	26-03-2019	Point 4(Turnol)	5 Hrs	15
16.	27-03-2019	Point 4(Turnol)	2 hrs	16
17.	28-03-2019	Point 4(Turnol)	4 hrs	14
18.	29-03-2019	Point 4(Turnol)	2 hrs	15
19.	30-03-2019	Point 5(IJP Road)	2 hrs	15
20.	31-03-2019	Point 5(IJP Road)	3 hrs	16
21.	02-04-2019	Point 5(IJP Road)	2 hrs	14
22.	03-04-2019	Point 5(IJP Road)	4 hrs	15
23.	05-04-2019	Point 6(Express Highway)	4 hrs	20
24.	06-04-2019	Point 6(Express Highway)	3 Hrs	16
25.	07-04-2019	Point 6(Express Highway)	3 hrs	14
26.	08-04-2019	Point 6(Express Highway)	2 hrs	15
27.	09-04-2019	Point 7(KRI Company)	3 hrs	15
28.	10-04-2019	Point 7(KRI Company)	3 hrs	16
29.	13-04-2019	Point 7(KRI Company)	3 hrs	14
30.	14-04-2019	Point 7(KRI Company)	3 hrs	14
31.	15-04-2019	Point 8(Barakau)	3 hrs	20
32.	16-04-2019	Point 8(Barakau)	2 hrs	20
33.	17-04-2019	Point 8(Barakau)	5 hrs	20

2.8 Interpretations of results

Reported results were interpreted in view of the scope and objectives of the study. Recorded emissions were compared with the standards. General conditions of the vehicles in Islamabad was also analyzed and recommendations were made accordable for the proper management and mitigations.

CHAPTER 3

RESULTS AND DISCUSSION

Interpreted results are being reported in this chapter based on categories into tested vehicles details and pollutants concentration

3.1 Tested vehicles details

During the monitoring phase, total 480 vehicles were tested, including cars, public transport buses, trucks, loading vans etc. These vehicles were using various types of fuels like CNG, Petrol and Diesel. Complete data collected during this campaign can be reviewed in appendix I. Vehicles by each fuel category are reported in figure 3.1.

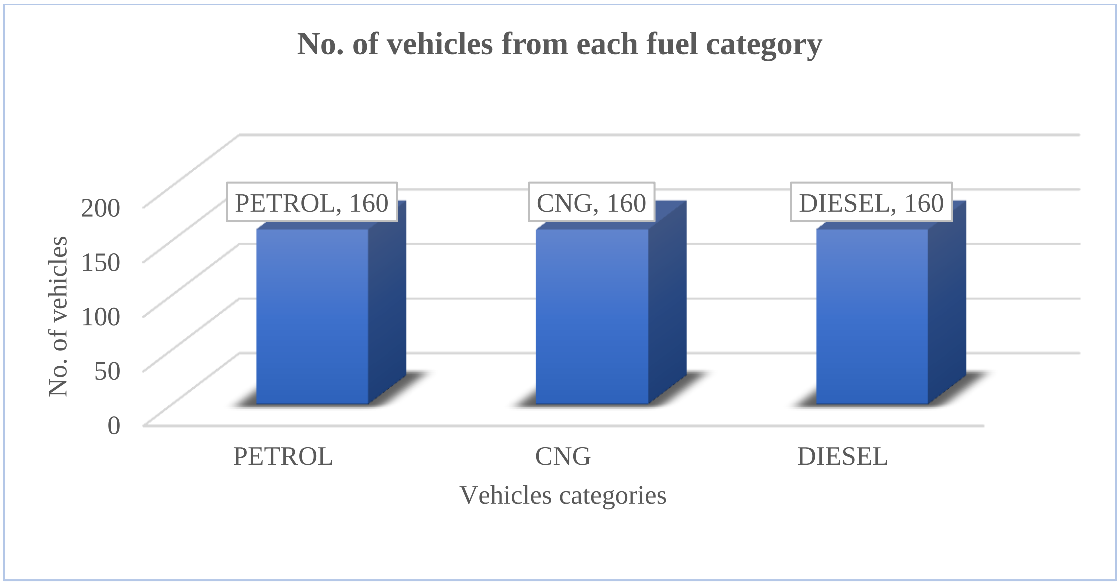


Figure 3.1 Total no. of tested vehicles

3.2 Pollutants concentrations

Concentrations of each pollutant were monitored and analyzed. Details of each pollutant are given below:

3.2.1. CO Concentrations

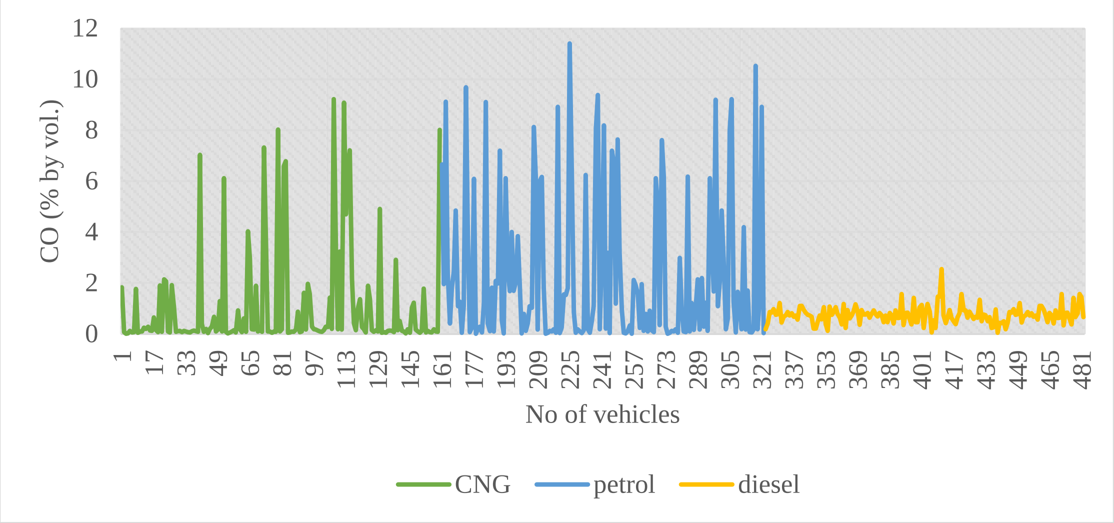


Figure 3.2: Observed CO level of Different fuel categories

In figure 3.2 concentration of carbon monoxide is given in CNG, petrol and diesel. Higher emission is in petrol and the array of emissions is as Petrol> Diesel> CNG. The situation depicts that petrol-fuelled vehicles have a tendency of higher CO levels (>10 vol. %) that indicates the incomplete combustion either due to lack of tuning of vehicles or insufficient supply of air through air filtration system (Sharaf, 2013). Air insufficiency can be managed through timely replacement of air filters. CO is the major threat to human health and higher level of CO inhalation from environment may cause serious damage to respiratory system and lungs (Levy, 2015). With the prolonged exposure adverse effects on neurological system were also noted (Evans et al., 2014), whereas the acute effects include headache, dizziness, vomiting, and nausea. Vehicles running on diesel comparatively showed lower level of CO than petrol and are following the limits implemented. CNG is considered a comparatively cleaner fuel for vehicles (Bielaczyc et al., 2016), and it shows a need to promote CNG fuels in private vehicles as well as in public transport buses.

3.2.2 CO_2 Concentrations

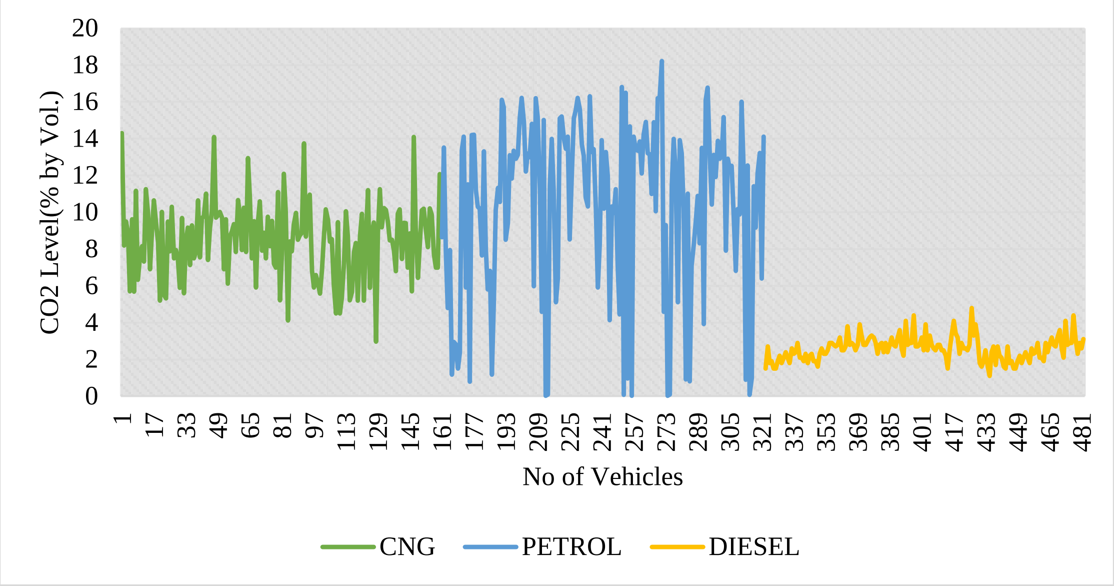


Figure 3.3: Observed CO_2 level of Different fuel categories

The levels of CO_2 recorded from vehicle testing data are shown in figure 3.3. Petrol based vehicles show variable trend for CO_2 levels ranging from 0 to 17 vol% along the CNG based vehicles which also show a variable trend from + 4 to 13 vol%. It depicts more favorable results as higher CO_2 level in a vehicle exhaust emission can be considered as optimal performance of vehicles with complete combustion of fuels. The fuel consists of organic molecules, which are mostly hydrocarbon (Kakaee et al., 2014). With environmental perspective, CO_2 is a potent greenhouse gas. The immense release of CO_2 from the vehicles are contributing towards global warming along urban air quality problems, such as photochemical smog and adversely affect human health (GFEI, 2017). The health impacts include headaches, dizziness, restlessness, a tingling or pins or needles sensation, choking, sweating, fatigue, higher pulse rate, elevated blood pressure and eventually coma, asphyxia, and convulsions (Krzyzanowski et al., 2005).

3.2.3 NOx Concentrations

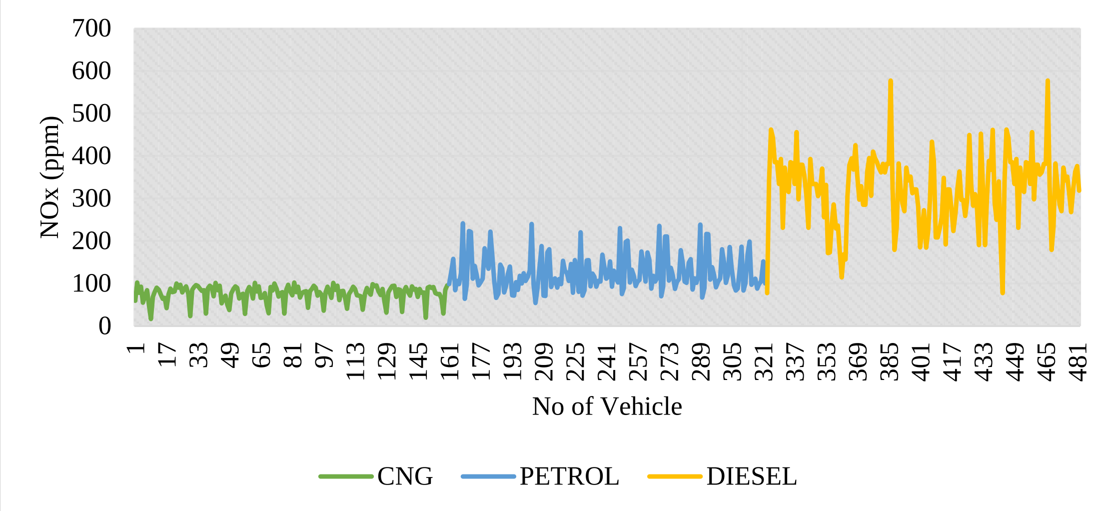


Figure 3.4: Observed NO_X level of Different fuel categories

Nitrous oxides are mainly emitting from the diesel-based vehicles as shown in figure 3.4 with 100- 500ppm. The factors for nitrogen oxide emissions from automobiles may include advanced injection timings, increase in compression ratio, turbo charging and low octane number of the fuels (Mukerjee,1988).

It is also a potent GHG with highest global warming potential of 310 CO_2 equivalents (IPCC 2007). The health impacts associated with nitrogen oxides are severe irritation, skin burning, and inflammation of the airways (Schurmann et al., 2007). These gases also react with other pollutants and facilitate the formation of secondary air pollutants (Ravishankara et al., 2009).

After release from the fuel combustion it cartels with oxygen to create nitric oxide (NO) that further combines with oxygen to create nitrogen dioxide (NO_2). Nitric oxide is not considered to be hazardous to health at typical ambient concentrations, but nitrogen dioxide can be (Erisman et al., 2013; Skalska et al., 2010). Nitrogen dioxide and nitric oxide are referred to together as oxides of nitrogen (NOx). The chemical reaction will be as:

$$O_2 + 2N_2 \rightarrow 2N_2 + N_2$$

$$N_2 + 2O_2 \rightarrow 2NO + O_2$$

$$N_2 + 2OH^- \rightarrow 2NO + H_2$$

3.2.4 HC Concentrations

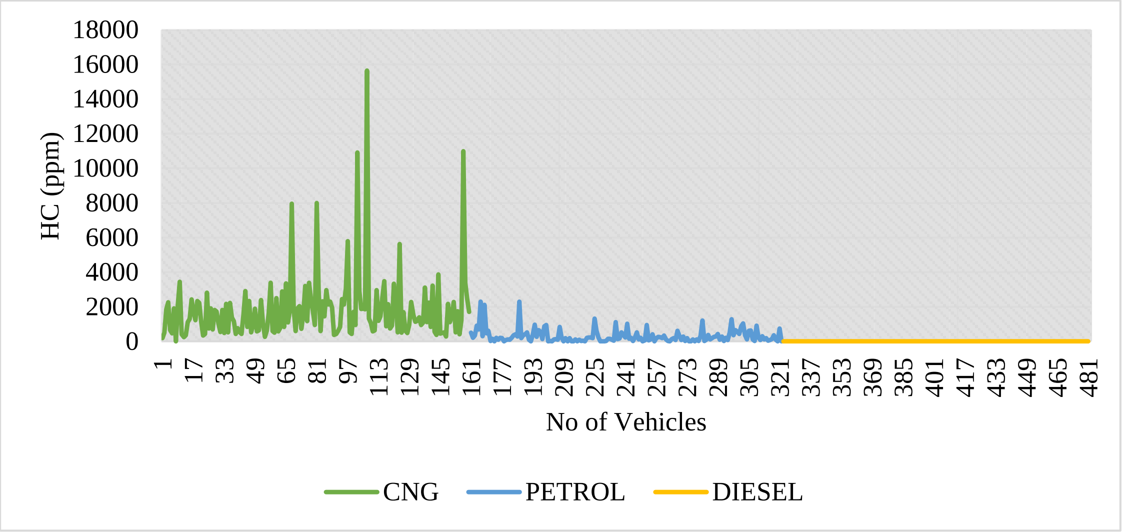


Figure 3.5: Observed HC level of Different fuel categories

Petrol based vehicles show improved levels of HC which can be interpreted as close to complete combustion of fuels in engine. It can further be brought closer to standard limits if regular tuning is done by vehicle owners as compared to CNG base vehicles as in figure 3.6. HC levels (>1500 ppm).The levels of hydrocarbons from diesel-based vehicles were not monitored due to their insignificance. Emissions of hydrocarbons indicate low combustion efficiency in internal combustion engines and they arise when vaporized unburned fuel or partially burned fuel products leave the combustion region and are emitted with the exhaust (Springer, 2012).

The global concerns about HC concentration are rising because it causes the formation of photochemical smog that has associations with irritation, chocking and eye burning. Furthermore, it hinders the sunlight top reach the surface and thus reduces the visibility and retards the process of photosynthesis (Abdel et al., 2016).

3.2.5 Oxygen

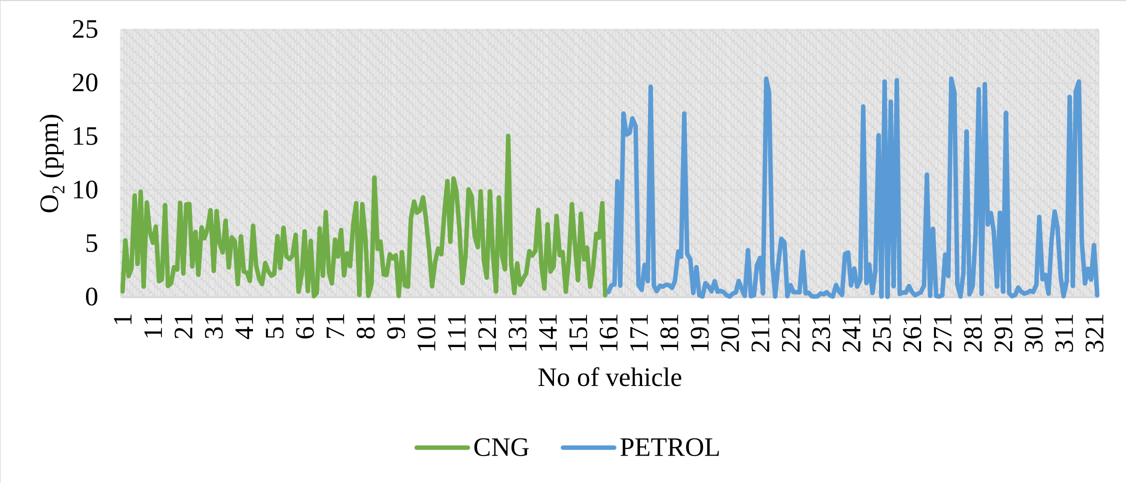


Figure 3.6: Observed O_2 level of Different fuel categories

In figure 3.6. Concentration of oxygen is shown in different fuel categories and observed the highest emission from CNG and petrol and the reason behind this is the incomplete combustion of hydrocarbon which leaves oxygen and water vapors. Diesel vehicles do not contribute in oxygen emission because in diesel almost complete combustion occur and leaves no oxygen behind.

Gasoline-powered engine burns gasoline in the presence of oxygen. Oxygen available to and utilized in an automobile engine is determined by number of elements. These include the temperature of air, elevation, temperature and load on vehicular engine, and barometric pressure (Gilles, 2012). Typically an O_2 sensor is present, which creates a voltage due to a chemical reaction resulting from an off-balanced gasoline to oxygen ratio. Most car engines can determine how much fuel to expend into the engine based on the voltage of the O_2 sensor. If your oxygen sensor fails to function properly, your engine management computer cannot determine the air to fuel ratio (Hakeem et al., 2016). Therefore, the engine is forced to guess how much gasoline to use, resulting in a polluted engine and a poorly functioning vehicle.

3.2.6 Opacity

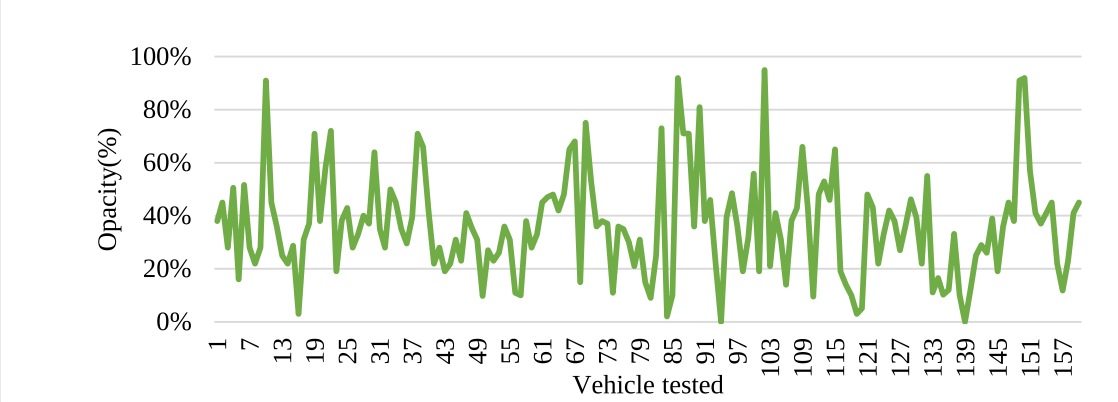


Figure 3.7: Opacity (%) from diesel vehicles from all sites

Opacity was tested from the 160 diesel-based vehicles; out of 160 vehicles 53 exceeded the permissible limit 40 HSU (Hartridge Smoke Unit) as shown in fig 3.7. On average, every diesel vehicle is producing 35% of opacity as observed from the selected locations. The key parameter to be noted is opacity in diesel vehicles because it's the function of diesel merely to produce opacity (Dogan, 2011). Opacity is the degree to which smoke, particulate matter and soot blocks the light, comprises of hydrocarbon particles, more is the susceptibility of unburnt hydrocarbon particles which ultimately effects on respiratory system (US-EPA, 2018)

3.3 Pollutants from major Automobiles brands

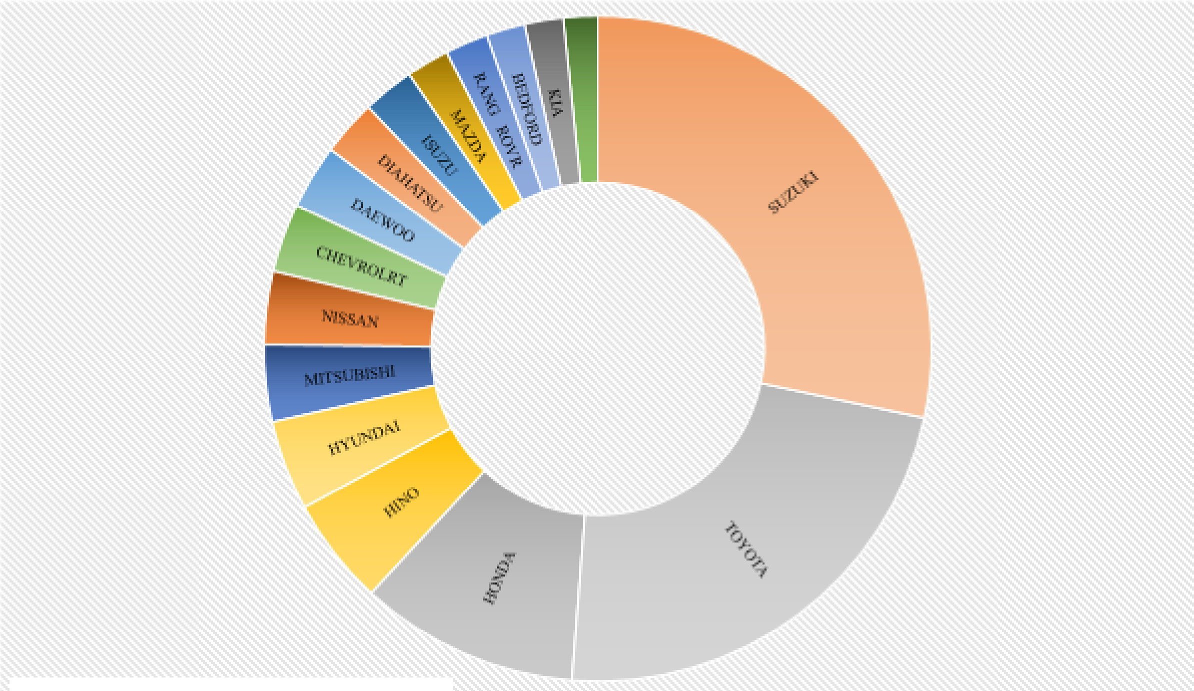
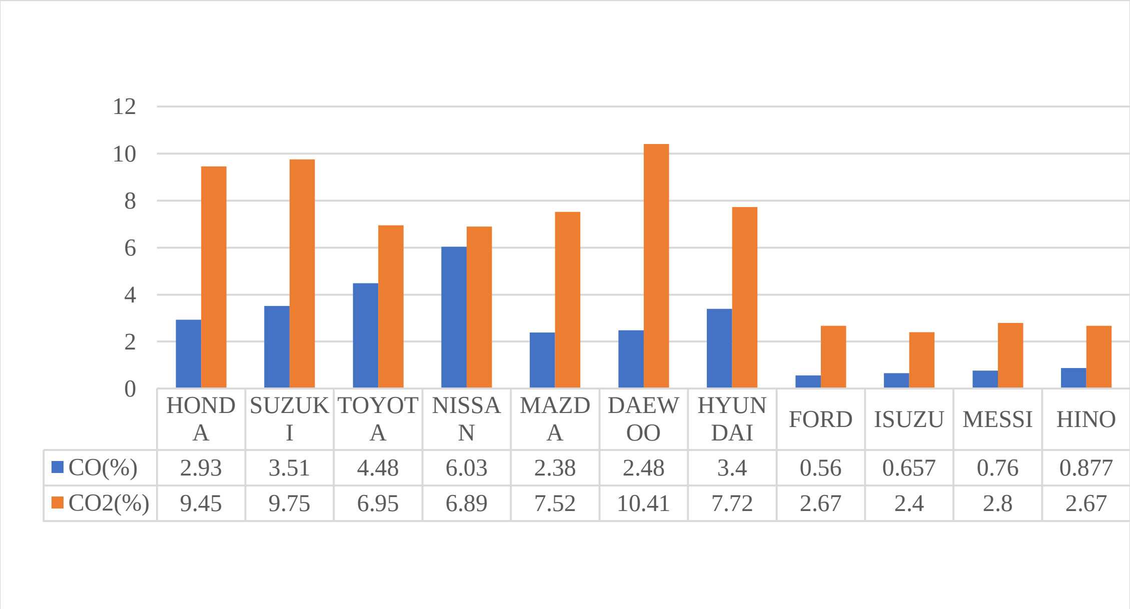


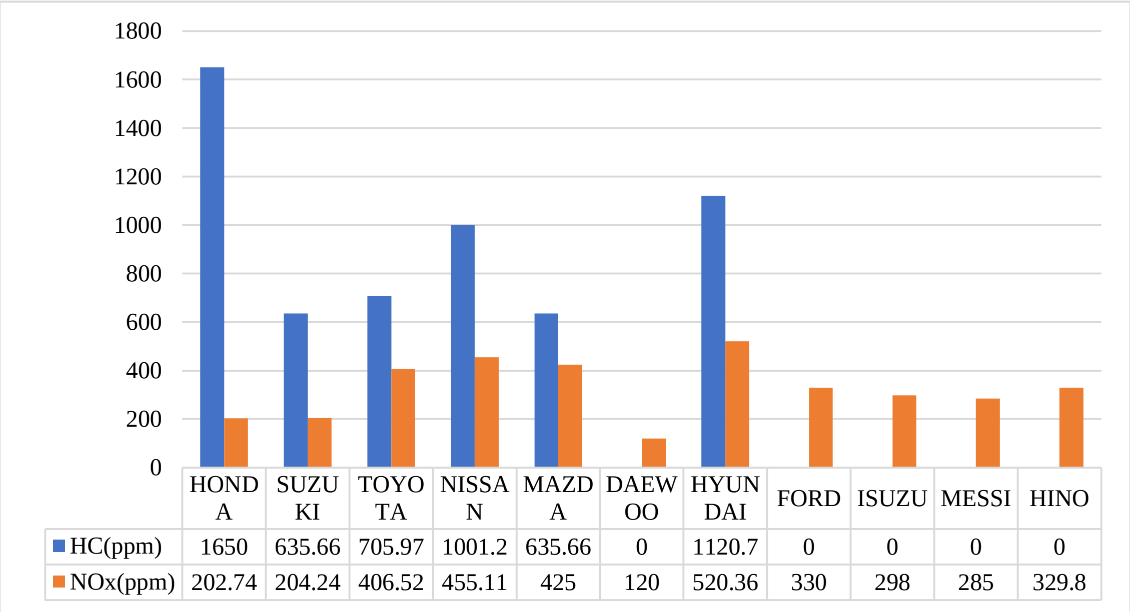
Figure 3.8: Vehicles categories

Most of the vehicular brands on road countered were of Suzuki, Honda and Toyota, Hino etc that includes mostly commercial vehicles and private cars. Average emissions from different brands are shown in figures 3.8



	HONDA	SUZUKI	TOYOTA	NISSAN	MAZDA	DAEWOO	HYUNDAI	FORD	ISUZU	MESSI	HINO
CO(%)	2.93	3.51	4.48	6.03	2.38	2.48	3.4	0.56	0.657	0.76	0.877
CO2(%)	9.45	9.75	6.95	6.89	7.52	10.41	7.72	2.67	2.4	2.8	2.67

Figure 3.9: Average CO and CO_2 emissions from different vehicular brands



	HONDA	SUZUKI	TOYOTA	NISSAN	MAZDA	DAEWOO	HYUNDAI	FORD	ISUZU	MESSI	HINO
HC(ppm)	1650	635.66	705.97	1001.2	635.66	0	1120.7	0	0	0	0
NOx(ppm)	202.74	204.24	406.52	455.11	425	120	520.36	330	298	285	329.8

Figure 3.10: Average HC and NOx emissions from different vehicular brands

Vehicles of Honda Motors, Suzuki and Daewoo were producing high level of CO_2 (figure 3.9). Commercial Suzuki, Nissan and Daewoo company's vehicles were found more in Islamabad and Rawalpindi due to a lot of educational, governmental and other private institutions. One of the main reasons also identified buses of many institutions are old model leading to high emissions (Clarket al., 2006). Emissions of

CO_2 from the natural gas big vehicles is lower than Emissions of diesel engine vehicles (Lyford, 2003).

In figure 3.10 Vehicles of Honda motors produce high level of hydrocarbon. CNG and Petrol engine vehicles generates more emissions of hydrocarbons that those of other road fuels. With CNG's being a heavy product, its combustion creates heavy unburned hydrocarbons. Different Studies shows that the composition of un-burnt hydrocarbons is close to the one found for the natural gas used in the test, which means that methane is in a large majority for CNG engines (Coroller and Plassat, 2003). Honda and Suzuki company vehicles found more in quantity on the road with high working pressure. Honda, Hyundai, Nissan and Suzuki vehicles were found mostly old modeled that tends to release more emissions than other companies.

Nissan motor vehicles were found with high in production of carbon monoxide (figure 3.9). Overloading of vehicles and road shape or structure also cause of high emission of carbon monoxide. In Islamabad Nissan company vehicles like dumpers are found in construction activities. These vehicles are found continuously in operation without rest and maintenance that is main cause of high emissions. CDA mostly use such type of vehicles for waste collection,

Hyundai, Mazda, Toyota, Nissan and Nissan motor vehicles produce high amount of NOx (figure 3.10). These vehicles are on diesel engines. Use of CNG leads to an important decrease in NOx emissions compared to Diesel vehicles; an average decrease of about 50% was observed overall tested fleet, no correlation could be set up between the combustion technologies and the NOx levels (Mitianiec, 2014). In comparison with Diesel-powered buses, CNG-powered vehicles lead to about a 50 per cent reduction of NOx emissions and a near-total absence of particles that could be improved using specific lubricant characteristics (Coroller and Plassat, 2003).

CONCLUSION

This study was conducted with the objectives to assess the air pollution level caused by vehicular emissions in the capital city Islamabad. Study plan was designed to fulfill the objectives of the research, Sampling of 480 vehicles were carried out based on three fuel categories i.e., Petrol, CNG and Diesel on the eight different locations of Islamabad city with the support of Pakistan Environmental Protection Agency (Pak-EPA), Islamabad Traffic Police (ITP) and National Transport Research Centre (NTRC). Cumulatively it was found that out of total 480 tested vehicles running on CNG, Petrol and Diesel fuels, highest Hydrocarbons are emitting from CNG fuel (i.e., 1818 ppm/vehicle) following the petrol with 311ppm/vehicle value. Petrol is emitting highest CO with 2.3% by vol. per vehicle. Diesel vehicles were found with highest NOx emissions as 320 ppm/vehicle. Smoke opacity was tested 160 (One hundred sixty) from diesel vehicles out of which 53 were exceeding the NEQS limit (40 HSU). Vehicles of Honda, Suzuki, Toyota and Daewoo brands were producing high level of CO, CO_2 and HC as the vehicles were commonly found old modeled leading to high emissions. Hyundai, Mazda, Toyota, and Nissan motor vehicles were found to produce high NOx concentration and smoke opacity. These vehicles were found continuously in operation without maintenance and rest that is main cause of high emissions. The results indicated that current situation of vehicular emissions in Islamabad is highly unsatisfactory and there is a need to form strategies which could later on be adopted at the national level.

RECOMMENDATIONS

We recommend the following crucial actions to reduce exhaust emission from vehicles based on the results of the study;

a) It should be ensured by legislative authorities that refineries and oil marketing companies comply with the fuel quality standard.

b) Implementation of Stringent Vehicular Emission Standards

c) Gas Stations should be subjected to regular audits for fuel quality and adulteration.

d) Implementation of Clean Fuel Programs.

e) More Public Awareness Campaigns to educate masses about various emission related health hazards.

f) Periodic mandatory inspection of vehicle emissions at vehicle inspection centres, by EPA or by independent inspection & testing Body.

g) There is a need to establish and enforce ambient air quality standards in Pakistan.

h) There is need to revise NEQS for motor vehicle exhaust.

i) Legislation should be framed to establish and enforce exhaust emission standards for vehicles.

j) Effort should be made by the Government to increase the number of environmental tribunals, ensure diesel and gasoline quality.

k) VETS facilities should be established in federal and extend to all major urban cities of Pakistan.

l) To minimize the air pollution measures adopted the improvement in the traffic flow and upgrade the public transport system.

m) EPA should made effort to establish the Vehicle Emission Testing System in Islamabad, later can be extended to cover other urban cities.

n) There also needs to train the traffic police staff to check the faulty vehicles for excessive smoke and noise.

o) EPA may take initiative to design a monitoring program for vehicle testing.

p) Strict measures should be taken by the government to check the adulteration of gasoline and the culprits should be severely dealt with under the law.

q) EPA should start comprehensive surveillance programme to check the monitoring and reporting system, strict check needs to be imposed on faulty vehicles that should be kept off the road unless they completely rectify all the faults and get fitness certificates.

r) Commercial vehicles have traditionally been checked by the traffic police and vehicle examiners. The public service vehicles are required to get fitness certificates periodically.

s) Substandard Spares of the vehicles should be banned on sale, their use may have adverse effects on engine and tend to increase vehicular emissions.

t) Sub-standard/recycled engine oils should be banned on sale such lubricating oils are not only harmful to engine but also add to environmental pollution.

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ANNEXURE- I

Supporting Data

1. Faizabad (CNG)

S.N0.	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HC PPM	CO2%	O2%	NOX PPM
01.	HONDA CIVIC	2000	1600	125,000	1.83	185	13.3	0.53	59
02.	HONDA CIVIC VIT	2003	1600	112,000	0.07	511	8.19	5.33	102
02.	HONDA CIVIC VIT	2001	1600	155,000	0.01	1848	9.5	1.97	78
03.	TOYOTA VITZ	2001	1000	117,000	0.02	2261	8.9	2.68	92
05.	TOYOTA VITZ	2005	1000	90,000	0.12	658	5.7	9.49	55
06.	TOYOTA VITZ	2009	1000	88,000	0.06	469	9.61	2.11	72
07.	DIAHATSU CHARADA	1987	1000	59,900	0.07	1915	5.69	9.85	84
08.	DIAHATSU CHARADA	1985	1000	65,200	1.77	28,50	11.17	0.98	48
09.	DIAHATSU CHARADA	1988	1500	99,999	0.05	2117	6.32	8.85	16
10.	DIAHATSU CHARADA	1986	1000	115,000	0.09	3439	7.61	6.19	68
11.	SUZUKI ALTO	2007	1000	45,900	0.1	412	8.16	5.09	80.5
12.	SUZUKI ALTO	2018	660CC	27,000	0.25	256	7.32	6.61	90
12.	SUZUKI ALTO	2008	1000	82,000	0.2	350	11.25	1.48	85
13.	SUZUKI ALTO	2005	1000	83,800	0.29	1121	9.91	1.65	72.5
15.	SUZUKI ALTO	2006	1000	81,998	0.13	1299	6.91	8.62	62.5
16.	SUZUKI KHYBER	1997	1000	85,890	0.12	2437	8.92	1.03	66
17.	SUZUKI KHYBER	1995	1000	77,058	0.65	1703	10.65	1.31	42
18.	SUZUKI KHYBER	1990	1000	95,000	0.15	1219	9.39	2.81	73.25
19.	SUZUKI KHYBER	1994	1000	100,000	0.07	2331	8.37	2.58	87.5
20.	SUZUKI KHYBER	1992	1000	100,000	1.91	2,223	5.19	8.81	79.25

Petrol

S.N	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HCPPM	CO2%	02%	NOX PPM
1.	SUZUKI	FX 1980	800	95000	6.66	499	8.65	0.48	98
2.	SUZUKI	RAVI 2006	800	88500	1.95	215	12.51	1.11	125
2.	SUZUKI	RAVI 2007	800	71200	9.12	346	7.92	1.18	158
3.	NISSAN	SUNNY 1978	1200	1,45000	2.41	921	3.80	10.81	84
5.	SUZUKI	BOLAN 1993	800	85662	0.41	685	7.95	1.07	106
6.	HONDA	CD-70 BIKE1985	70	65000	1.82	2291	1.17	17.16	98
7.	UNITED	UNITED 70 2007	70	39500	2.45	299	2.95	15.19	124
8.	HONDA	CD-702002	70	41700	3.84	2122	2.83	15.33	241
9.	HONDA	CD-70 2004	70	15900	1.09	465	1.50	16.71	64
10.	HONDA	125-2009	125	17900	1.27	611	2.38	15.95	96
11.	SUZUKI	SURF-2018	1300	11200	0.05	19	12.36	1.13	223
12.	DAIHATSU	MIRA-2007	660	95000	1.09	146	13.11	0.69	221
12.	DAIHATSU	MIRA-2016	660	13800	9.68	9.19	5.91	2.02	111.5
13.	DAIHATSU	TERIOS-2010	1500	15500	2.7	219	11.51	1.49	141
15.	DAIHATSU	MOVE-2017	660CC	7460	0.07	91.5	0.79	19.66	121
16.	DAIHATSU	MIRA-2010	660	95200	0.23	208	13.19	1.07	95
17.	DAIHATSU	CHARADE-1983	1000	75000	6.09	198	13.21	0.55	102
18.	SUZUKI	CULTUS VXL 2019	1000	260	0.01	12	11.20	1.08	111
19.	SUZUKI	CULTUS VXL 2016	1000	52500	0.18	87	10.29	0.98	182.5
20.	SUZUKI	SWIFT-2010	1300	62000	0.29	122	10.20	1.16	152.5

Diesel

S.NO	MAKE	MOD EL	ENGINE SIZE	SMOKE	HC ppm	NOx ppm	CO2%	CO%	OPACITY %
1.	MAZDA TRUCK	1980	3500	Yes	0.0	77	1.5	0.18	35%
2.	HYUNDAI SHAHZO OR	2006	2200	No	0.0	342	2.7	0.42	19%
2.	MAZDA BUS	1995	3500	No	0.0	462	1.8	0.86	11%
3.	TCM LIFTER	1991	3500	Yes	0.0	443	1.9	0.84	92%
5.	HYUNDAI SHAHZOR	2006	2200	No	0.0	385	1.5	0.98	9.8%
6.	HYUNDAI SHAHZOR	2005	2200	No	0.0	385	1.5	0.75	38%
7.	HYUNDAI SHAHZOR	2007	2000	No	0.0	334	1.9	0.78	27%
8.	ISUZU	2005	4000	No	0.0	393	2.2	1.21	33%
9.	HYUNDAI SHAHZOR	2006	2200	No	0.0	231	1.8	0.45	36%
10.	MAZDA BUS	1998	3500	Yes	0.0	372	2.1	0.69	68%
11.	BEDFORD TRUCK	1960	6000	No	0.0	323	2.4	0.73	28%
12.	HYUNDAI SHAHZOR	2006	2200	No	0.0	315	2.1	0.86	35.5%
12.	MAZDA	1990	3500	No	0.0	385	1.8	0.72	42%
13.	HINO TRUCK	1993	7000	No	0.0	382	2.6	0.81	33%
15.	HINO TRUCK	1987	7500	No	0.0	334	2.3	0.67	19%
16.	MAZDA BUS	1986	3500	Yes	0.0	456	2.4	0.72	38%
17.	TOYOTA HILUX	1995	2200	No	0.0	298	2.9	0.56	22%
18.	HYUNDAI SHAHZOR	2008	2200	No	0.0	379	2.1	1.1	11%
19.	HYUNDAI SHAHZOR	2007	2200	No	0.00	379	2.1	1.1	22%
20.	HYUNDAI SHAHZOR	2005	2200	No	0.0	356	1.9	0.95	31%

2. Pirwadai (CNG)

S.no	MAKE	MODEL	ENGINE SIZE	MILAGE	CO %	HC PPM	CO2 %	O2%	NOX PPM
01.	TOYOTA CROLLA	2002	1300	195,631	0.08	1131	10.01	2.21	80.75
02.	SUZUKI ALTO	2007	1000	28,129	2.15	339	5.49	8.66	100
02.	SUZUKI ALTO	2007	1000	29,122	2.07	437	5.31	8.71	90
03.	TOYOTA COROLLA	2004	1300	95,400	0.09	2821	9.5	2.88	97
05.	MITSUBISHI LANDCRUSER	2006	1600	39,000	0.06	755	7.88	6.11	78.5
06.	SUZUKI MEHRAN	1992	800	99,800	1.92	1902	10.29	2.10	87
07.	SUZUKI MEHRAN	2003	800	110,000	1.02	699	7.49	6.50	93
08.	SUZUKI HIROOR (BOLAN)	1988	800	48,400	0.08	1815	7.95	5.51	75
09.	SUZUKI HIROOR (BOLAN)	2001	800	65,900	0.11	1721	7.45	6.41	23
10.	TOYOTA COROLLA	2004	1300	78,500	0.12	1025	5.90	8.12	85
11.	DIAHATSU COURE	2008	1000	17,500	0.07	550	9.68	2.45	91.25
12.	TOYOTA COROLLA	1998	1300	120,866	0.12	1819	5.60	8.03	96
12.	SUZUKI MEHRAN	2009	800	95,000	0.09	496	8.38	5.09	92.5
13.	SUZUKI MEHRAN	1998	800	99,300	0.07	2171	9.17	3.19	87.75
15.	SUZUKI MEHRAN	2006	800	88,000	0.06	531	7.12	7.13	82.75
16.	HYUNDAI CENTRO	2004	1000	17,000	0.11	2221	9.29	2.79	84
17.	SUZUKI MEHRAN	2005	800	139,000	0.13	1384	7.50	5.59	29
18.	SUZUKI HIROOF BOLAN	2005	800	41,200	0.11	1171	7.80	5.24	88.25
19.	SUZUKI LIANA	2007	1300	23,800	0.08	440	10.65	1.22	93.75
20.	HONDA CITY	2003	1300	122,000	**7.03**	766	7.55	5.68	90.625

Petrol

S.N	MAKE	MODEL	ENGINE SIZE	MILAGE	CO %	HCPPM	CO2%	02%	NOX PPM
01.	SUZUKI	SWIFT-2018	1300	10,000	0.06	99	7.65	1.14	133.5
02.	SUZUKI	BALENO-2000	1300	250,000	1.20	217	12.31	0.85	222
02.	SUZUKI	BALENO-2005	1300	185,056	**9.11**	356	8.02	1.56	166
03.	SUZUKI	MEHRAN-2018	800	3700	0.41	421	5.80	3.28	106
05.	SUZUKI	MEHRAN-2015	800	28,000	0.11	285	6.82	2.77	66
06.	SUZUKI	MEHRAN-2013	800	50,500	1.82	2291	1.17	17.16	76
07.	SUZUKI	MEHRAN-2008	800	100,000	0.09	198	5.11	3.02	143.5
08.	SUZUKI	MEHRAN-2004	800	155,000	2.08	356	10.12	2.52	135.5
09.	SUZUKI	MEHRAN-2001	800	160,000	1.98	411	11.32	0.39	79
10.	SUZUKI	MEHRAN-2017	800	25,100	7.19	519	10.55	2.82	93.5
11.	SUZUKI	KHYBER-1998	1000	98,000	0.53	101	16.11	0.19	123
12.	TOYOTA	VITZ 2018	1000	4500	0.02	8.5	15.71	0.07	140
12.	TOYOTA	COROLLA-2008	1300	55,800	6.11	399	8.5	1.31	72
13.	SUZUKI	CULTUS-1998	1000	68,900	2.48	967	9.41	0.98	71.5
15.	SUZUKI	MEHRAN-1987	800	96,500	1.68	267	12.10	0.52	102.5
16.	SUZUKI	MARGALLA-1994	1300	59,800	**3.01**	657	11.82	1.49	85
17.	HONDA	CIVIC-2007	1300	92,100	1.69	559	12.35	0.51	118
18.	HONDA	CITY-2008	1300	25,300	2.05	132	12.91	0.59	100
19.	SUZUKI	FX-1987	800	75,800	2.84	882	12.11	0.47	124
20.	NISSAN	SUNNY	1600	10,55000	1.97	942	15.10	0.19	106

Diesel

S.NO	MAKE	MODEL	ENGINE SIZE	SMOKE	HC ppm	NOx ppm	CO2%	CO%	OPACITY %
01.	MAZDA BUS	1988	3500	No	0	304	2.3	0.84	15%
02.	MAZDA BUS	1994	3500	Yes	0	231	1.8	0.75	53%
02.	TOYOTA HILUX	2008	2200	Yes	0	393	2.2	0.73	46%
03.	HYUNDAI SHAHZOR	2004	2200	No	0	334	2.3	0.67	23%
05.	BEDFORD TRUCK	1960	7000	Yes	0	334	1.9	0.21	91%
06.	MAZDA BUS	1992	3500	Yes	0	334	1.9	0.21	65%
07.	BUS NISSAN	2008	3500	Yes	0	305	1.6	0.48	45%
08.	BUS HINO	2014	3500	No	0	316	2.3	0.72	35%
09.	BUS HINO	2012	3500	No	0	370	2.6	0.57	28%
10.	BUS HINO	2004	3500	Yes	0	256	2.3	1.05	50%
11.	ISUZU NPR	2009		Yes	0	332	2.3	0.38	47%
12.	ISUZU NPR	2008		No	0	171	2.5	0.12	45%
12.	RANG ROVR SPORT	2007	2700 CC	No	0	173	2.9	1.07	16%
13.	TOYOTA HILUX	2018	2800 CC	No	0	242	2.9	0.75	22%
15.	DAHON SHAHZOR	2018	2600 CC	No	0	286	2.8	0.87	03%
16.	SHAHZOR	2008	2600 CC	No	0	229	2.7	1.05	31%
17.	DAISHTU	2014		No	0	236	2.8	0.79	28%
18.	TOYOTA HILUX D-4D	2013	3000	Yes	0	174	2.2	0.64	39%
19.	NISSAN QASHQIN	2009	1500	No	0	114	2.5	0.37	30%
20.	TOYOTA PARADO	1996	3000	No	0	168	2.5	1.18	19%

2. Rawat T Cross (CNG)

S.N0.	MAKE	MODEL	ENGINE SIZE	MILAGE	CO %	HC PPM	CO2%	O2%	NOX PPM
01.	DIAHATSU COURE	2008	850	9,248	0.38	551	9.68	2.38	69.875
02.	SUZUKI KHYBER	2009	1000	51,000	0.08	439	9.77	2.26	101
02.	SUZUKI MEHRAN	2002	800	60,000	0.2	1550	11.01	1.51	84
03.	SUZUKI HIROOF BOLAN	2006	880	85,400	0.03	2905	7.41	6.65	93.5
05.	SUZUKI MEHRAN	2005	800	21050	0.2	832	9.10	2.06	52.5
06.	NISSAN SUNNY	1989	1000	84,000	0.29	2333	10.04	1.7	62.5
07.	SUZUKI CULTUS	2010	1000	22,800	0.68	519	13.1	1.21	71
08.	SUZUKI ALTO	2006	1000	94,000	0.1	939	9.71	2.19	49.5
09.	SUZUKI HIROOF BOLAN	2010	800	31,066	0.17	1892	9.82	2.45	37
10.	SUZUKI CULTUS	2007	1000	60,000	1.29	583	10.01	2.01	76.5
11.	SUZUKI ALTO	2009	1000	94,000	0.1	639	9.71	2.19	86.85
12.	SUZUKI HIROOF BOLAN	2002	800	70,800	**6.11**	2386	6.91	5.70	93
12.	SUZUKI HIROOF BOLAN	2001	800	45,000	0.08	1058	9.61	2.72	89.25
13.	SUZUKI MEHRAN	2018	800	5,000	0.02	260	6.12	6.48	63.5
15.	HONDA CITY	2005	1300	26,000	0.06	619	8.71	2.82	72.25
16.	HUNDAI COROLLA	2004	1000	71,000	0.09	1649	8.97	2.55	75.5
17.	TOYOTA COROLLA	1996	1300	21,900	0.14	3395	9.36	2.88	28.5
18.	SUZUKI ALTO	2011	1000	39,000	0.06	592	7.84	5.83	81.75
19.	SUZUKI CULTUS	2006	1000	59,500	0.92	505	10.66	0.49	91.25
20.	TOYOTA COROLLA	2000	1300	41,900	0.19	2497	9.81	2.16	83.75

Petrol

S.N	**MAKE**	**MODEL**	**ENGINE SIZE**	**MILAGE**	**CO%**	**HCPPM**	**CO2%**	**02%**	**NOX PPM**
01.	SUZUKI	VEGNOR	1000	12,000	0.02	7.9	16.21	0.07	116
02.	SUZUKI	VAGAN-R2015	1000	19,500	0.79	28	13.91	0.32	131
02.	SUZUKI	VAGAN-R2018	1000	21,000	0.12	8.9	12.21	0.45	240
03.	SUZAKI	VAGON-R2015	1000	28,836	0.41	112	12.19	1.51	97
05.	SUZUKI	VAGON-2015	1000	45,827	1.09	128	12.99	0.71	54
06.	HONDA	CITY-2019	1300	8,968	1.02	92.5	13.8	0.12	87
07.	HONDA	CITY-2005	1300	112,205	8.12	839	5.98	3.38	134
08.	HONDA	CITY-2003	1300	194,392	6.22	223	16.19	0.09	188
09.	HONDA	ACCORD-2006	2400	93,000	0.17	11.8	15.19	0.17	71.5
10.	HONDA	ACCORD-2003	2000	85,000	6.02	188	11.21	2.99	70.25
11.	HONDA	CIVIC-1996	1600	180,000	6.17	9.21	3.58	2.67	173
12.	HONDA	CIVIC-2016	1800	19000	1.81	186	15.02	0.37	180.5
12.	HONDA	CIVIC-2019	1800	30	0.01	5.9	0.02	20.41	91.5
13.	HONDA	CIVIC-2018	1800	2,300	0.05	11	0.09	19.11	106.25
15.	SUZUKI	BOLAN-2001	800	82,756	0.12	112	11.45	2.19	111.75
16.	TOYOTA	VITZ-2014	1000	61,000	0.09	12	12.99	0.05	90
17.	TOYOTA	VITZ-2005	1000	13,3000	0.18	98	11.19	2.21	110
18.	TOYOTA	COROLLA-2015	1600	58,117	0.05	26	5.11	5.48	98
19.	TOYOTA	COROLLA-1999	1300	125,000	**8.92**	53	6.39	5.12	153
20.	TOYOTA	COROLLA-2018	1300	7,025	0.03	9.5	15.11	0.09	129

Diesel

S.NO	MAKE	MODEL	ENGINE SIZE	SMOKE	HC ppm	NOx ppm	CO2 %	CO%	OPACITY %
01.	TOYOTA LAND CRUISER	1999	4200		0	156	2.7	0.24	22%
02.	TOYOTA COROLLA 2.0D	2000	2000	Yes	0	305	2.8	0.94	95%
02.	JW FOR LAND BRAVO	2018	1800		0	378	2.8	0.61	2%
03.	TOYOTA COROLLA 2.0D	2009	2000	No	0	394	2.9	0.72	21%
05.	TOYOTA HILUX	2017	3000	No	0	368	2.8	0.89	33%
06.	TRUCK HINO	2017	3500	No	0	425	2.5	1.16	22%
07.	BUS HINO	1999	2500	No	0	350	2.8	0.88	35%
08.	BUS HINO	2007	3000	Yes	0	297	2.9	0.36	45%
09.	BUS MAZDA	1993	2000	No	0	329	2.3	0.94	36%
10.	TRUCK HINO	1994	2500	No	0	285	2.8	0.76	28%
11.	TRACTOR MESSI	2008	1500	Yes	0	285	2.8	0.76	45%
12.	BUS HINO	2008	2000	No	0	364	2.0	0.82	29.5%
12.	TRUCK HINO	1997	1900	Yes	0	395	2.2	0.64	42%
13.	TRUCK ROCKET	1995	2200		0	306	2.3	0.79	28%
15.	TRUCK SHAHZOR	2002	2500	No	0	410	2.2	0.92	22%
16.	TOYOTA HILUX VIGO	2012	3000	Yes	0	395	2.9	0.77	38%
17.	TOYOTA REVO	2017	3000	No	0	386	2.3	0.69	19%
18.	TOYOTA LAND CRUSIER	2019	2500	No	0	372	2.8	0.83	0%
19.	TOYOTA HIACE	1991	2500	Yes	0	361	2.9	0.72	71%
20.	TOYOTA HIACE	1995	2000	No	0	381	2.4	0.46	36%

3. Turnol (CNG)

S.N0.	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HC PPM	CO2%	O2%	NOX PPM
01.	SUZUKI ALTO	2010	1000	45,800	0.07	585	7.95	6.17	63.45
02.	SUZUKI CULTUS	2009	1000	38,000	0.61	789	10.25	0.55	101.5
02.	TOYOTA COROLLA	1998	1300	28,000	0.08	2897	7.85	5.25	81
03.	SUZUKI CULTUS	2004	1000	75,000	3.03	838	12.95	0.1	92.25
05.	SUZUKI CULTUS	1997	1000	80,000	2.96	3345	10.81	0.42	65.95
06.	SUZUKI HIROOF BOLAN	2002	800	135,000	0.19	1091	7.50	6.41	67.80
07.	DIAHATSU COURE	2004	850	89,000	0.17	1784	9.51	1.99	77.4
08.	HYUNDAI TAXI	1993	1300	45,000	1.89	7961	5.91	7.95	48
09.	SUZUKI BALANO	2003	1200	19,778	0.09	1865	9.45	2.32	30
10.	SUZUKI MEHRAN	2007	800	2,61,896	0.17	595	10.6	1.28	91.5
11.	SUZUKI MEHRAN	2000	800	73,900	0.08	1905	7.91	5.38	83
12.	SUZUKI BOLAN HIROOF	1997	1000	5,613	**7.32**	2041	8.89	2.79	99.5
12.	SUZUKI ALTO	2004	1000	70,000	2.71	728	7.5	6.28	87.125
13.	TOYOTA COROLLA	2005	1300	59,396	0.10	1555	9.75	2.02	69
15.	DIAHATSU CHARADE	1984	1300	1,35,000	0.09	3198	8.15	3.09	77
16.	SUZUKI CULTUS	2006	1000	487,000	0.05	1180	9.53	2.9	79.5
17.	SUZUKI CULTUS	2009	1000	38,565	0.09	3392	7.19	6.85	29
18.	NISSAN SUNNY	1998	1300	37,565	0.08	2446	6.98	8.78	85
19.	SUZUKI CULTUS	2006	1000	40,000	**8.02**	1745	11.09	0.21	97
20.	SUZUKI CULTUS	2009	1000	38,238	0.09	948	5.21	8.71	81.5

Petrol

S.N	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HCPPM	CO2%	02%	NOX PPM
01.	HONDA	CIVIC VIT	1600		0.25	205	15.21	1.12	125
02.	HONDA	CIVIC VIT	1600		1.55	228	13.01	0.47	106
02.	HONDA	CIVIC VIT	1600		1.53	230	12.45	0.46	146
03.	HONDA	CIVIC VIT	1800		1.79	198	13.11	0.45	78
05.	SUZUKI	KHYBER-2000	1000	97,200	11.41	1322	8.52	3.24	153.5
06.	TOYOTA	COROLLA-2002	1300	57,500	6.12	621	12.2	0.37	125
07.	SUZUKI	CULTUS-2007	1000	1,900	0.85	225	15.10	0.41	80
08.	HONDA	CITY-2008	1300	9,900	0.05	9	15.55	0.09	220
09.	HONDA	CITY-2007	1300	14,200	0.18	10.9	16.21	0.05	71
10.	TOYOTA	VITZ-2003	1000	40,100	0.09	9	15.58	0.09	83
11.	TOYOTA	VITZ-1999	1000	75,600	0.03	26	12.69	0.37	154
12.	TOYOTA	VITZ-2003	1000	55,900	0.14	148	12.07	0.28	155
12.	DIAHATSU	COURE-2000	850	27,862	6.24	163	10.81	0.48	93
13.	SUZUKI	BOLAN-1991	800	95,900	0.19	93	10.31	0.18	122.5
15.	TOYOTA	VITZ-2005	1000	5,523	0.05	45	16.31	0.05	116
16.	SUZUKI	MEHRAN-1985	800	100,000	0.49	1119	12.28	1.12	92.5
17.	HONDA	CIVIC-2006	1300	63,000	1.09	139	12.43	0.56	106
18.	SUZUKI	MARGALLA-1994	1300	51,000	8.05	176	10.11	0.21	103.5
19.	SUZUKI	FX-1987	800	54,500	**9.38**	519	5.91	3.02	167.75
20.	SUZUKI	CULTUS-2000	1000	59,000	0.18	371	8.3	3.19	140.5

Diesel

S.NO	MAKE	MODEL	ENGINE SIZE	SMOKE	HC ppm	NOx ppm	CO2%	CO%	OPACITY%
01.	TOYOTA COASTUR	2001	4000	Yes	0	361	2.9	0.72	55%
02.	TOYOTA COASTER	2014	4000	No	0	381	2.4	0.46	31.7%
02.	TOYOTA COASTER	1993	4000	Yes	0	381	2.8	0.82	55.9%
03.	TOYOTA COASTER	1991	3700	Yes	0	577	2.2	0.72	71.1%
05.	HINO TRUCK	1997	2500	Yes	0	325	2.8	0.41	66%
06.	HINO BUS	2006	3000	No	0	179	2.7	0.92	31%
07.	MAZDA HINO BUS	2007	2500	No	0	233	2.2	0.62	35.9%
08.	HINO TRUCK	2004	2000	No	0	382	2.6	0.63	38.3%
09.	TOYOTA HIACE	1992	2500	Yes	0	324	2.6	1.56	57%
10.	TOYOTA HIACE DX	2017	2700	No	0	287	2.2	0.35	32.2%
11.	TOYOTA HIACE MIDROOF	2012	2000	No	0	270	3.1	0.83	29%
12.	TOYOTA HIACE	2016	2700	No	0	372	2.8	0.84	11.1%
12.	TOYOTA HIACE	2015	2700	No	0	342	2.9	0.58	16.5%
13.	TOYOTA HIACE	2014	2700	No	0	351	2.9	0.37	14%
15.	TOYOTA HIACE	2013	2700	No	0	312	3.4	1.42	38.1%
16.	TOYOTA HIAC	2011	2700	Yes	0	321	2.7	0.46	41%
17.	TOYOTA HIACE	2018	2700	No	0	321	2.7	0.46	19%
18.	TOYOTA HIACE	1997	2800	Yes	0	281	2.8	1.04	43%
19.	TOYOTA HIACE	2009	3000	Yes	0	185	2.2	1.14	66%
20.	TOYOTA HIACE	1990	2600	Yes	0	224	2.5	0.23	43%

5. IJP Road (CNG)

S.No.	MAKE	MODEL	ENGINE SIZE	MILAGE	CO %	HC PPM	CO2%	O2%	NOX PPM
01.	HONDA CIVIC	1988	1300	2,39,558	0.19	7985	7.71	5.52	72.21
02.	NISSAN SUNNY	1998	1300	1,22,000	**6.59**	2881	12.09	0.11	101.75
02.	SUZUKI FAX	1980	800	85,000	**6.78**	599	10.01	1.22	79.5
03.	NISSAN SUNNY	1985	1000	3,38,520	0.05	2327	3.11	11.18	92.6
05.	SUZUKI MEHRAN	1999	800	99,800	0.06	1448	8.42	3.51	67
06.	TOYOTA COROLLA	1986	1300	62,500	0.09	2958	7.88	5.21	77
07.	SUZUKI KHYBER	1999	1000	1,22,000	0.08	2128	9.32	2.11	80.5
08.	SUZUKI KHYBER	1990	1000	1,15,000	0.17	2299	9.96	2.06	82
09.	SUZUKI PICKUP RAVI	1997	800	72,000	0.87	1951	8.50	2.99	43
10.	SUZUKI PICKUP RAVI	2009	800	35,318	0.07	370	8.75	2.6	81.75
11.	SUZUKI - C RAVI	2002	800	65,000	0.09	441	8.87	2.91	87.125
12.	SUZUKI - C RAVI	2011	800	12,500	1.62	615	12.75	0.13	93.75
12.	SUZUKI BOLAN	2002	800	63,000	0.17	837	8.67	3.21	90.30
13.	NISSAN SUNNY	1974	1200	1,45,000	1.97	2439	10.51	1.09	71.25
15.	TOYOTA COROLLA	1974	1200	1,15,000	1.57	2138	10.95	0.98	79.85
16.	NISSAN SUNNY	1973	1200	1,17,300	0.29	3049	6.84	7.31	72.75
17.	TOYOTA COROLLA	1978	1300	1,22,000	0.19	5788	5.91	8.93	35.5
18.	SUZUKI KHYBER	1995	1000	78,000	0.17	528	6.59	7.88	79.25
19.	SUZUKI ALTO	1999	660	98,300	0.13	431	6.19	8.11	92.25
20.	SUZUKI PICKUP BOLAN	1994	800	97,000	0.09	1714	5.58	9.31	80.3

Petrol

S.N	MAKE	MODEL	ENGINE SIZE	MILAGE	CO %	HCPPM	CO2%	02%	NOX PPM
01.	SUZUKI	CULTUS-2003	1000	62,500	2.91	228	12.91	1.09	111.5
02.	SUZUKI	MEHRAN-1997	800	71,000	8.19	1021	10.19	2.69	115.5
02.	HONDA	CIVIC-2005	1600	50,000	0.21	147	12.28	0.98	152
03.	DIAHATSU	COURE-2007	850	25,500	2.19	215	11.99	1.61	92
05.	TOYOTA	COROLLA-	2000	2,000	0.03	19	3.13	17.81	130.25
06.	SUZUKI	KHYBER-1996	1000	15,900	7.20	228	10.31	1.32	111.5
07.	NISSAN	SUNNY-1998	1600	10,5000	6.72	517	9.96	2.05	102
08.	DAIHATSU	CHARADE-	1000	79,6500	1.19	115	11.25	0.39	230
09.	SUZUKI	FX-1986	800	10,5944	7.63	204	7.08	2.48	75
10.	SUZUKI	ALTO-		1,954	2.19	8.55	3.45	15.11	88.75
11.	SUZUKI	ALTO-		39,000	0.94	68	16.8	0.05	198
12.	HONDA	CIVIC VIT	1600		0.04	945	0.08	20.15	200.75
12.	HONDA	CIVIC VIT	1600		0.02	58	16.5	0.02	102
13.	HONDA	CIVIC VIT	1600		0.09	115	0.96	18.27	132
15.	HONDA	CIVIC VIT	1600		0.33	405	13.66	1.02	118.5
16.	HONDA	CIVIC VIT	1300		0.01	12	0.02	20.26	92.75
17.	HONDA	CIVIC VIT	1800		2.12	199	13.11	0.29	103.5
18.	HONDA	CIVIC VIT	1600		1.92	271	12.41	0.45	107.75
19.	HONDA	CIVIC VIT	1600		1.55	241	12.35	0.41	173.87
20.	HONDA	CIVIC VIT	1600		0.23	200	12.85	1.03	146.25

Diesel

S.NO	MAKE	MODEL	ENGINE SIZE	SMOKE	HC ppm	NOx ppm	CO2%	CO%	OPACITY%
01.	TOYOTA HIACE HIROOF	2019	2500	No	0	272	2.9	0.83	03%
02.	TOYOTA HIACE	2005	2800	Yes	0	184	2.5	1.18	**41%**
02.	TOYOTA HIACE MID ROOF	2019	2500	No	0	221	2.3	0.88	12%
03.	TOYOTA HIACE STANDARD	1992	2800	Yes	0	298	2.8	0.06	**48%**
05.	NISSAN X TRAIL	2006	2500	No	0	433	2.6	0.54	21%
06.	HINO TRUCK	2003	3000	Yes	0	387	2.5	0.24	**40%**
07.	HINO DUMPER	2001	4000	Yes	0	208	2.8	1.47	**72%**
08.	HINO BUS	2011	3500	No	0	208	2.8	1.47	37%
09.	HINO TRUCK	1991	3000	Yes	0	232	2.5	2.54	**62.9%**
10.	HINO TRUCK	1961	2500	Yes	0	257	2.5	0.73	**43%**
11.	SHAHZOR	2016	1800	No	0	348	2.2	0.42	15%
12.	SHAHZOR	2017	2000	No	0	192	1.5	0.66	09%
12.	SHAHZOR	2011	1600	No	0	321	2.5	0.94	25%
13.	SHAHZOOR	2001	1200	Yes	0	321	2.3	0.62	**50.6%**
15.	SHAHZOR	1997	1000	Yes	0	276	3.1	0.49	**73%**
16.	DAEWOO BUS	2014	2500	No	0	223	2.4	0.38	25%
17.	TOYOTA PICKUP	2005	2500	No	0	268	2.2	0.66	36%
18.	TOYOTA PICKUP	2001	3000	Yes	0	325	2.3	0.81	39.5%
19.	TOYOTA JEEP	1988	2500	No	0	363	2.9	1.56	36.2%
20.	HINO BUS	1992	2200	Yes	0	296	2.6	0.92	**71%**

6. Express highway (CNG)

S.N0.	MAKE	MODEL	ENGINE SIZE	MILAGE	CO %	HC PPM	CO2%	O2 %	NOX PPM
01.	SUZUKI PICKUP RAVI	2011	800	17,000	0.08	958	6.81	7.33	65.60
02.	SUZUKI PICKUP RAVI	2006	800	63,200	0.14	10921	8.60	3.38	101
02.	NISSAN SUNNY	1974	1300	1,22,000	0.29	2923	10.15	1.02	83.75
03.	SUZUKI-C- BOLAN	2003	600	65,600	0.27	1877	9.58	2.31	93.85
05.	HUNDAI-T	2002	1300	72,800	1.43	1904	8.39	3.55	61
06.	SUZUKI BOLAN	1992	800	41,039	0.2	1848	8.53	2.99	82
07.	SUZUKI PICK UP	1982	800	1,29,000	**9.22**	15,637	6.08	7.72	82.25
08.	NISSAN SUNNY GL	1972	1200	1,25,000	2.11	1318	3.50	10.85	65
09.	SUZUKI PICKUP BOLAN	1983	800	1,35,000	0.18	1066	9.46	5.17	40
10.	SUZUKI PICKUP RAVI	1987	800	1,12,000	2.24	589	3.50	11.08	73.85
11.	SUZUKI PICKUP BOLAN	1988	800	97,300	0.17	639	5.30	9.95	82.5
12.	NISSAN SUNNY GL	1978	1200	99,200	**9.08**	2973	7.22	6.21	92.35
12.	SUZUKI PICKUP BOLAN	1984	800	77,000	3.69	1181	10.05	1.32	87
13.	DATSUN-T	1980	1300	65,000	**6.52**	1445	8.69	2.95	72.15
15.	NISSAN	1979	1300	100,000	**7.21**	2541	5.22	10.07	71
16.	SUZUKI BOLAN	1989	800	100,000	2.15	3476	5.66	9.41	69.35
17.	SUZUKI BOLAN	1998	800	75,000	0.41	881	7.81	5.77	38
18.	SUZUKI BOLAN	1993	800	50,662	0.15	2145	8.33	3.65	76
19.	TOYOTA HIACE	1992	1300	78,300	0.98	753	5.20	9.89	89
20.	TOYOTA HIACE	1988	1300	1,22,000	1.37	904	8.71	2.41	79.25

Petrol

S.N	MAKE	MODEL	ENGIN E SIZE	MILAGE	CO%	HCPPM	CO2 %	02%	NOX PPM
01.	Hyundai	i-10-2013	1600	41469	1.95	342	12.10	0.49	103.5
02.	SUZUKI	VEGN-R-2017	1000	28,000	0.12	112	13.21	0.17	173
02.	SUZUKI	VAGAN-R2015	1000	19,500	0.79	28	13.91	0.32	155
03.	SUZUKI	VAGAN-R2018	1000	22,000	0.09	9.9	12.21	0.45	88
05.	SUZAKI	VAGON-R2015	1000	29,636	0.91	142	12.15	1.11	118.25
06.	SUZUKI	SWIFT-2015	1300	42000	0.15	187	10.99	11.45	103.5
07.	HONDA	CITY-2019	1300	7,963	0.07	72.2	13.9	0.11	113
08.	TOYOTA	COROLLA-2004	1300	86,780	**6.12**	619	10.05	6.38	235.5
09.	HONDA	CITY-2009	1300	114,391	5.10	313	16.20	0.13	69.5
10.	HONDA	ACCORD-2005	2400	93,890	0.35	81.7	16.19	0.07	92.35
11.	HONDA	ACCORD-2003	2000	85,300	**7.61**	278	18.21	0.19	210.5
12.	HONDA	CIVIC-1996	1600	185,000	**6.18**	19.11	3.58	2.97	210.5
12.	SUZUKI	BOLAN-1991	800	96,800	0.29	188	9.31	1.98	106.5
13.	HONDA	CIVIC-2019	1800	30	0.01	5	0.02	20.41	136.5
15.	HONDA	CIVIC-2018	1800	2,300	0.05	11	0.09	19.11	119.75
16.	SUZUKI	BOLAN-2001	800	82,756	0.12	112	11.45	1.19	87
17.	TOYOTA	VITZ-2014	1000	61,000	0.09	12	12.99	0.05	102.75
18.	TOYOTA	VITZ-2005	1000	13,5000	0.19	122	12.17	2.31	109.75
19.	TOYOTA	COROLLA-2015	1600	58,117	0.05	26	5.11	15.48	178.25
20.	SUZUKI	CULTUS-2003	1000	63,900	2.98	321	12.92	0.28	149.25
21	SUZUKI	MEHRAN-1983	800	120,000	0.99	1215	12.21	1.02	103.5

Diesel

S.NO	MAKE	MODEL	ENGIN E SIZE	SMOKE	HC ppm	NOx ppm	CO2 %	CO%	OPACITY %
1.	ISUZU TROPPER	1988	2800	Yes	0	296	2.6	0.92	**48%**
2.	TOYOTA HILUX	2007	3000		0	259	2.5	0.64	22%
2.	TOYOTA COASTER	1991	3000		0	296	2.8	0.87	38%
3.	TOYOTA COASTER	1982	3200	Yes	0	449	3.8	0.72	**91%**
5.	JW-FOLAND BRAVO	2014	2700		0	329	2.3	0.58	10%
6.	HYUNDAI SHAHZOR	2008	2200		0	283	2.9	0.67	28%
7.	HYUNDAI SHAHZOR	2007	2000		0	310	2.2	0.63	26%
8.	MAZDA BUS	2002	4000		0	275	1.8	1.34	36%
9.	HYUNDAI SHAHZOR	2007	2200		0	190	1.6	0.50	31%
10.	MAZDA BUS	1996	3500	Yes	0.0	452	1.9	0.76	**75%**
11.	BEDFORD TRUCK	1970	6000		0.0	333	2.5	0.74	**45 %**
12.	HYUNDAI SHAHZOR	2006	2200		0	190	1.6	0.50	31 %
12.	MAZDA	1992	3500	Yes	0.0	300	1.1	0.66	**48%**
13.	HINO TRUCK	1994	7000		0	388	2.4	0.23	37%
15.	HINO TRUCK	1991	7500		0	367	2.7	0.26	28%
16.	MAZDA BUS	1986	3500	Yes	0.0	461	1.7	0.96	37%
17.	TOYOTA HILUX	1995	2200		0	290	2.7	0.05	**42%**
18.	HYUNDAI SHAHZOR	2009	2200		0	250	2.2	0.43	10%
19.	HYUNDAI SHAHZOR	2007	2200		0	340	2.1	0.42	23%
20.	HYUNDAI SHAHZOR	2001	2200		0	190	1.6	0.50	**41%**

7. Karachi company (CNG)

S.N0.	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HC PPM	CO2%	O2%	NOX PPM
01.	TOYOTA HIACE	1994	3000	1,33,000	0.27	3341	9.92	1.81	72.17
02.	TOYOTA HIACE	1990	3500	1,47,200	0.18	2281	5.20	9.89	98.5
02.	TOYOTA HIACE	2007	2000	100,000	0.06	533	8.52	3.11	92.75
03.	TOYOTA COROLLA	1991	1300	1,23,456	1.89	5621	11.20	0.53	95
05.	TOYOTA PRADO	1990	3378	48,000	1.37	504	5.90	9.33	81.5
06.	SUZUKI KHYBER	1992	1000	100,000	0.14	1681	8.81	2.82	72.85
07.	SUZUKI LIANA	2006	1300	1,05,000	0.08	621	9.45	2.60	87
08.	CHEVROLRT JOY	2009	1000	87,000	0.14	496	2.96	15.06	57.25
09.	SUZUKI ALTO	2004	800	100,000	0.09	971	8.91	2.22	31.5
10.	DAIHATSU CHARADA	1984	1000	2,80,000	3.91	2279	11.25	0.39	79
11.	TOYOTA COROLLA	2007	1300	200,000	0.05	1521	9.19	2.18	87.3
12.	HYUNDAI SANTRO	2007	1000	74,000	0.07	1140	10.22	1.15	93.15
12.	SUZUKI CULTUS	2008	1000	72,000	0.05	1181	10.12	1.75	93.75
13.	SUZUKI CULTUS	2004	1000	60,523	0.12	1392	9.50	2.22	68
15.	SUZUKI CULTUS	2012	1000	51,000	0.13	948	8.46	3.3	86.5
16.	SUZUKI MEHRAN	2011	800	85,800	0.12	1071	8.50	2.87	85
17.	SUZUKI MEHRAN	2002	800	1,12,000	0.07	3110	7.91	3.33	33
18.	SUZUKI MEHRAN	2001	800	1,10,000	2.91	1119	6.80	8.16	82
19.	SUZUKI CULTUS	1996	1000	66,300	0.15	2246	9.91	2.89	91.9
20.	SUZUKI CULTUS	2009	1000	48,000	0.51	832	10.16	0.81	81

Petrol

S.N	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HCPPM	CO2%	02%	NOX PPM
01.	SUZUKI	Every-2013	660	24845	0.09	28.9	10.21	5.88	101.25
02.	SUZUKI	SWIFT-2015	1300	18,800	0.07	99.5	0.91	19.42	149
02.	SUZUKI	BALENO-2000	1300	255,300	**6.18**	386	11.01	0.29	157
03.	Toyota	PASSO-2015	1000	22,220	0.09	111.8	0.81	19.9	85.5
05.	TOYOTA	VITZ-2016	1000	4200	1.21	186	7.11	6.78	112.05
06.	SUZUKI	MEHRAN-2015	800	29,000	0.16	266	8.3	7.87	101.25
07.	TOYOTA	COROLLA-2015	1500	76,000	1.09	291	9.51	6.11	118.5
08.	SUZUKI	MEHRAN-2008	800	105,000	2.15	425	10.88	0.98	238
09.	MITSUBISHI	MIRAGE-2015	1000	16899	0.17	93.8	8.31	7.88	66.5
10.	SUZUKI	MEHRAN-2001	800	165,000	2.19	288.5	12.5	0.49	89
11.	SUZUKI	MEHRAN-2016	800	29,800	0.28	28.7	2.92	17.22	216.75
12.	SUZUKI	KHYBER-1998	1000	99,000	1.23	211	16.12	0.39	215.75
12.	TOYOTA	COROLLA 2007 GLI	1300	2,00000	0.12	88.5	16.78	0.08	109
13.	TOYOTA	COROLLA-2004	1300	93,530	**6.11**	499	12.9	0.21	138.5
15.	DAEWOO	RACER-2002	1500	58,900	2.48	1288	10.41	0.88	120
16.	MAZDA	DEMIO-2006	1300	92,800	1.67	367	12.11	0.52	91
17.	SUZUKI	MARGALLA-1994	1300	89,800	**9.19**	657	11.92	0.32	103.5
18.	HONDA	CIVIC-1995	1500	2,18000	1.09	569	12.88	0.42	110.85
19.	KIA	SPORTAGE-2002	2000	2,55,300	2.05	432	12.91	0.58	180.375
20.	SUZUKI	FX-1987	800	95,800	**3.84**	882	12.11	0.47	150.85
01.	NISSAN	SUNNY	1600	10,68300	2.91	1042	15.17	1.17	101.25

Diesel

S.NO	MAKE	MODEL	ENGINE SIZE	SMOKE	HC ppm	NOx ppm	CO2 %	CO %	OPACITY
1	TOYOTA HIACE	1991	2500	No	0.0	77	1.5	0.18	37%
2	TOYOTA HIACE DX	2018	2700	No	0.0	342	2.7	0.42	10.2%
3	TOYOTA HIACE MIDROOF	2014	2000	No	0.0	462	1.8	0.86	26 %
4	TOYOTA HIACE	2017	2700	No	0.0	443	1.9	0.84	10.2%
5	TOYOTA HIACE	2015	2700	No	0.0	385	1.5	0.98	12 %
6	TOYOTA HIACE	2018	2700	No	0.0	385	1.5	0.75	9.5 %
7	TOYOTA HIACE	1990	2600	Yes	0.0	334	1.9	0.78	**48.1%**
8	TOYOTA HIAC	2011	2700	No	0.0	393	2.2	1.21	31%
9	TOYOTA HIACE	2018	2700	No	0.0	231	1.8	0.45	14%
10	TOYOTA HIACE	1995	2800	Yes	0.0	372	2.1	0.69	**53%**
11	TOYOTA HIACE	2009	3000	Yes	0.0	323	2.4	0.73	**46%**
12	TOYOTA HIACE	1988	2600	Yes	0.0	315	2.1	0.86	**65%**
13	TOYOTA HIACE HIROOF	2019	2500	No	0.0	385	1.8	0.72	5 %
14	TOYOTA HIACE	2006	2800	Yes	0.0	382	2.6	0.81	**41%**
15	DAEWOO BUS	2010	2500	No	0.0	334	2.3	0.67	22%
16	TOYOTA PICKUP	2000	2500	Yes	0.0	456	2.4	0.72	**45%**
17	TOYOTA PICKUP	1997	3000	Yes	0.0	298	2.9	0.56	**48.5%**
18	TOYOTA JEEP	1988	2500	No	0.0	379	2.1	1.1	**46.2%**
19	HINO BUS	1992	2200	No	0.00	379	2.1	1.1	38 %
20	BUS HINO	2004	2000	Yes	0.0	356	1.9	0.95	39.5%

8. Barakahu (CNG)

S.N0	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HC PPM	CO2%	O2%	NOX PPM
01.	SUZUKI CULTUS	1988	1000	1,33,000	0.12	3219	7.45	6.8	71.5
02.	DIAHATSU COURE	2008	800	48,202	0.09	561	9.42	2.40	93
02.	DIAHATSU HIJET	2014	660	35,000	0.02	380	9.40	2.88	85.6
03.	DIAHATSU CHARADA	1987	1000	200,000	0.19	3866	6.99	7.58	87
05.	DIAHATSU HIJET	2013	660	30,000	0.05	446	8.86	2.90	68.2
06.	DAIHATSU COURE	2001	800	88,553	1.03	481	5.70	3.22	87
07.	SUZUKI LIANA	2011	1300	66,300	1.23	522	13.1	0.51	78
08.	SUZUKI ALTO	2015	1000	11,000	0.17	288	9.18	2.45	79
09.	SUZUKI KHYBER	1995	1000	99,200	0.09	2171	6.43	8.70	19
10.	HONDA CENTRO	2011	1000	48,200	0.05	1119	8.33	5.07	90
11.	SUZUKI MEHRAN	2002	800	61,000	0.12	1550	10.11	1.59	92
12.	SUZUKI MEHRAN	1989	800	85,200	1.78	2281	10.19	7.81	89
12.	SUZUKI MEHRAN	2007	800	68,000	0.06	521	8.99	2.52	91.3
13.	SUZUKI BOLAN	2005	800	49,200	0.12	1742	8.11	3.62	77
15.	SUZUKI BOLAN	2008	800	32,340	0.07	422	10.21	0.98	75
16.	SUZUKI KHYBER	2000	1000	87,300	0.06	1219	9.88	2.66	75
17.	HONDA CIVIC	1988	1300	2,39,558	0.19	10985	7.71	5.92	63.45
18.	SUZUKI CULTUS	2009	1000	38,565	0.09	3385	6.99	5.57	29
19.	NISSAN SUNNY	1998	1300	37,565	0.08	2446	6.98	8.78	85
20.	SUZUKI CULTUS	2006	1000	40,000	8.01	1708	12.07	0.19	95

Petrol

S.N	MAKE	MODEL	ENGINE SIZE	MILAGE	CO%	HCPPM	CO2%	02%	NOX PPM
01.	SUZUKI	CULTUS-2000	1000	60,100	0.19	362	7.91	7.49	117.85
02.	SUZUKI	VAGAN-R2015	1000	21,240	0.60	115	12.91	1.66	185.5
02.	TOYOTA	COROLLA-1999	1300	125,000	**8.01**	622.8	12.39	2.08	137
03.	SUZUKI	CULTUS-1998	1000	12,2885	**9.22**	642	12.52	0.34	95.75
05.	SUZUKI	VAGON-2014	1000	48,825	1.28	125.8	9.98	5.17	83
06.	HONDA	CITY-2019	1300	7,800	0.06	29.3	6.81	8.01	88
07.	SUZUKI	FX-1986	800	13,5944	1.65	904	10.18	6.51	131.5
08.	SUZUKI	MEHRAN-2010	800	85,000	1.15	221	9.88	1.88	186.75
09.	HONDA	ACCORD-2006	2400	95,322	0.18	71.8	16.00	0.08	83
10.	DIAHATSU	COURE-2004	850	95,540	3.19	312	11.98	1.51	100
11.	Toyota	PASSO-2012	1000	82,920	0.17	122	0.90	18.7	169.80
12.	SUZUKI	RAVI 2008	800	71200	1.71	188	12.55	1.05	198.125
12.	HONDA	CTY-2017	1300	41800	0.07	44	0.08	19.21	97
13.	DAIHATSU	MOVE-2018	660CC	3420	0.06	82.0	0.99	20.16	105
15.	SUZUKI	BOLAN-2001	800	85,916	0.18	141	11.41	5.20	111.25
16.	SUZUKI	KHYBER-1992	1000	112,000	**10.53**	351	9.17	1.29	88
17.	TOYOTA	VITZ-2007	1000	108000	0.18	98.9	12.11	2.66	99
18.	SUZUKI	MEHRAN-1985	800	115,000	1.49	7.15	12.22	1.65	104
19.	TOYOTA	COROLLA-1998	1300	130,000	**8.92**	753	6.40	3.88	152
20.	TOYOTA	COROLLA-2018	1300	6825	0.03	10.8	13.11	0.18	100

Diesel

S.NO	MAKE	MODEL	ENGIN E SIZE	SMOK E	HC ppm	NOx ppm	CO 2%	CO%	OPACITY %
2.	TRUCK	1992	7500		0	361	2.9	0.72	38%
3	TOYOTA HIACE	2018	2500	No	0	381	2.4	0.46	10%
4	TOYOTA HIACE	2002	2800	Yes	0	381	2.8	0.82	**45%**
5	TOYOTA HIACE MID ROOF	2018	2500	No	0	577	2.2	0.72	25%
6	TOYOTA HIACE STANDARD	1994	2800	Yes	0	325	2.8	0.41	42.2%
7	DAEWOO BUS	2008	2500	No	0	179	2.7	0.92	28.7%
8	TOYOTA HILUX VIGO	2014	3000	Yes	0	233	2.2	0.62	27%
9	COASTER	1990	3000		0	382	2.6	0.63	41%
10	COASTER	1983	3200	Yes	0	324	2.6	1.56	92%
	TOYOTA HIACE DX				0	286	2.1	0.34	
11	SHAHZOR	2010	2200		0	270	3.1	0.83	11.8%
12	SHAHZOR	2007	2200		0	372	2.8	0.84	23%
13	TOYOTA HIACE	1990	2500	Yes	0	342	2.9	0.58	81%
14	TOYOTA HIACE	1995	2000	No	0	351	2.9	0.37	38%
15	TOYOTA COROLLA	2011	2000	No	0	312	3.4	1.42	19%
16	TOYOTA PICKUP	1997	3000	Yes	0	268	2.2	0.66	36%
17	TOYOTA JEEP	1988	2500	No	0	325	2.3	0.81	39.5%
18	HINO BUS	1992	2200	No	0	363	2.9	1.56	58 %
19	BUS HINO	2004	2000	Yes	0	376	2.6	1.44	71%
20	SHAHZOOR	2001	1200	Yes	0	318	2.1	0.66	51.6%