NOx Emissions from Light Weight Vehicles

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Summary: The objective of this presentation is to evaluate quality of air in terms of emissions of nitrogen oxide released from two stroke and four stroke operating vehicles selected from various industries and to compare the efficiency of engines and fuels (CNG, Petrol and Diesel). It was observed that in 43 samples tested for NOx emissions by - non dispersive infra-red technology (NDIR), the switching of fuel from gasoline and diesel to compressed natural gas and two strokes to four stroke engines reduce the air emission burden. The concentration of NOx varies in the range from 0.0 to 20.5% for four-stork and 9.4-45.4% in two stroke engines while the reduction in concentration was 0.1 to 0.15 with the use of CNG.

Introduction

Three principal anthropogenic sources of air pollution are vehicular emissions, industrial pollution and the burning of municipal wastes. In almost all the large cities of the world, air pollution from motor vehicles are fast becoming major problems for physical and mental health of the people. Since 1960, the world's motor vehicle fleet has been growing faster than its population. The problems are acute in big cities both in the developing as well as the industrialized world and unless controls are applied or strengthened immediately, the damage to public health will become very serious.

Vehicles are responsible for 70 percent of environmental air pollution in Pakistan. Many metropolitan areas are not meeting the air quality standards. The country vehicle fleet has been growing at an annual rate of almost 15 percent with two stroke rickshaws, motorcycles and diesel vehicles of all types. It is estimated that some six million vehicles on the roads in the country, of which less than a million are on CNG, while most of other use inferior quality fuel [1]. Two hundred twelve thousand, four hundred and seventeen (2,12,417) vehicles were added in the fleet of Five hundred seventy three thousand, seven hundred thirty four (5,73,734) from year 2005 to 2006 in Lahore city [2].

The principal types of automobiles used in our country are two, three and four wheelers, powered by two stroke petrol engine, passenger cars, powered by four stroke petrol engine, trucks and buses, powered by four stroke diesel engines *etc.* The extent of pollution by these auto mobiles depend upon the engine design, fuel composition, operating conditions *e.g.* idling, cruising, acceleration and decelerations. The emission from engines are classified as exhaust, evaporative and crank care emissions. In this presentation only monitoring of exhaust emissions is carried out.

A substantial portion of the gas and vapors emitted to the atmosphere in appreciable quantity from anthropogenic sources tends to be relatively simple in chemical structure; carbon dioxide, carbon monoxide, sulfer dioxide and nitric oxide from combustion processes; hydrogen sulfide and ammonia source. The solvents and gasoline fractions that evaporate are alkenes, and aromatics with relatively simple structure. The above substances emitted directly from sources, are called primary pollutants and they are certainly not innocuous. These pollutants have various toxic effects on man, vegetation, livestock and materials [3-6]. Primary pollutants and the constituents of the unpolluted atmosphere under go chemical reactions and are responsible for most of smog, haze, eye irritation and many of the forms of plant and material damage called the secondary pollutants [7].

The exhaust emissions from gasoline powered vehicles are the most difficult to control, these emission are influenced by such factors as gasoline formulation, air fuel ratio ignition timing, compression ratio, engine speed and load, engine deposits, engine conditions, coolant temperature and combustion chamber configuration and as a function

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of drinking water idling acceleration crusing deceleration.

Since transportation sector accounts for major contribution of the entire global emission, from gasoline fed internal combustion engines, lot of attention and efforts have been directed towards controlling emission from this sector.

In this study, air monitoring is carried out with reference to exhaust emissions from automobiles with respect to the total oxides of nitrogen. In this context, The Asian Development Bank in its report on Urban air Quality Management in Pakistan has suggested stopping import and manufacture of two stroke vehicles, restriction of conversion of petrol-powered engines to diesel engines, better traffic management at high pollution spots, and capacity building of motor vehicle examiners can reduced the overall air pollution problems with respect to automobile exhaust emissions [1].

Results and Discussion

Because mobile sources of air pollution are capable of moving from one local Jurisdiction to another, they are usually regulated by the Federal Government, Pakistan EPA (Environment Protection Agency) in 1997 has presented NEQS (National Environmental Quality Standards) for motor vehicular exhaust emission lacking in providing standards for NOx [8]. Standards defined for automobile exhaust emissions are properly implemented in Pakistan that is why USA standards for vehicular exhaust for light duty automobiles [9] primary and secondary air quality standards for nitrogen dioxide are all time dependent [10].

Exposure to high levels of motor vehicle pollutants occurs in three situations.

a) While inside vehicles (from the immediately surrounding traffic).
b) While working in or walking alongside congested street
c) Through residence in neighborhood with high motor vehicle traffic pollution.

The objective of air pollution control is to prevent adverse responses by all receptor categories exposed to the atmosphere- human, animal, vegetable, and material. These adverse responses have characteristic response to times, short term (*i.e,* seconds or minutes), intermediate-term (*i.e,* hours and days) and long-term (*i.e,* months or years) effect on health. For there to be no adverse responses, the pollutant concentration in the air must be lower than the concentration level at which these responses occur [11].

Exhaust emission vary depending on the driving mode as shown in Table-1 which gives typical exhaust gas constituents from an uncontrolled vehicle as a function of driving mode. During idling, most engines require rich mixture to compensate for residual combustion products in the cylinder. Thus, CO emissions are high during idling as compared to acceleration, cruising and deceleration state.

Table-1: Exhaust emission of NOx from two stroke engine operated vehicles.

Sr. No.	Manufacture Name	Vehicle type	Nature of fuel	Emission from mobile sources NO_x %
1.	Eagle Brand	2 wheeler Motorcycle	Gasoline	18.2
2.	Royal Star	"	Gasoline	17.3
3.	Crown Brand	"	Gasoline	45.4
4.	Star Asia	"	Gasoline	12.2
5.	Pak Hero	"	Gasoline	22.3
6.	Tiger Brand	"	Gasoline	16.5
7.	Pak Asia	"	Gasoline	9.4
8.	Metro Runner	"	Gasoline	40.6
9.	Saggar Brand	3 wheeler Auto Rickshaw	Gasoline	18.7
10.	New Asia	"	Gasoline	10.3

Hydrocarbons are high in deceleration state and oxides of nitrogen are high in acceleration state [12].

Many countries have introduced legislation to abate air pollution by traffic. Setting emission standards for exhaust gas does this. Low emission can be obtained by using a so-called 3-way catalyst to oxidize CO and hydrocarbons and reduce NOx or by engine modifications (so-called lean burn engines) [13]

Oxides of nitrogen especially NO_2 is responsible for classical smog, Haze of polluted cities can cause respiratory problems in sensitive individual for example is Asthmatic and young children. Extensive analysis of available studies show an approximate 24% increase of respiratory illness for children who have increase exposure under the polluted environment. Human symptoms and effects on vegetation, material and visibility increases with

the passage of exposure time. The emission limits adopted by the United States for new light duty automobile are less than the emission limits of other countries [14].

From the data presented in Table-2, it is observed that NOx emissions are maximum for diesel-powered vehicles ranging from 65.0 to 20.5%. (Table-2). Control of emissions from diesel-powered vehicles is partially or completely accomplished from fuel modification (gasoline to CNG) and proper tuning of engine etc. Exhaust odor, smoke and NOx emissions from diesel engines are objectionable as compared to gasoline/ CNG fueled engines. For example green Punjab project launched by Provincial Government in which green rickshaws were converted from gasoline/diesel to CNG, resulting in the reduced emission from 0.0-1.2%. NOx in three wheeler, two stroke rikshaws which were (9.4-45.4%) in gasoline powered engines (Table-1). While in four stroke engines, the NOx emission was found to be in the range of 5.2-19.0%.

NOx emissions from 2-stroke engine exhaust are mentioned in Table-1. Two stroke engines do not have the capacity to run on CNG so all the vehicles (motorcycles and rickshaws) are operated on gasoline. Two-stroke engines can be expensive as it do not use fuel efficiency, produce more pollution because every time a new mixer of air/fuel is loaded into the combustion chamber. The maximum environmental emission level for NOx was found 45.4% and 40.4% in 2-stroke motorcycle (Crown Brand) and 2-stroke rickshaw (Metro Runner). While five values for NOx exhaust emission in Table-1 are within the range of 16.5-22.3 % and other values found in the range of 9.4-12.2%.

CNG: Compressed Natural Gas

The maximum NOx exhaust emission was found in the range of 20.5-65.0 % from diesel-operated vehicle. The gasoline powered vehicles emission range was 8.6-14.4 % NOx. With the modification in engine making and fuel source, the range was found to be reduced to 0.1- 0.15 % NOx as observed in CNG operated vehicles (Table-2).

Experimental

Mobile monitoring is accomplished from a mobile platform such that a vehicle. Emissions are measured by source monitoring techniques. The harmful effects of air pollution can be assessed only on the basis of adequate data collected using well defined sampling and analytical techniques.

Table-2: Exhaust emission of NOx from four stroke engine operated vehicles

Sr. No.	Name and Brand of Vehicle	Vehicle Type	Nature of fuel	Emission from mobile sources NO_x (oxide of nitrogen) %
1.	Sohrab	2 wheeler CD70 motorcycle	Gasoline	14.4
2.	New ASADA	"	Gasoline	15.3
3.	Atlas Honda	"	Gasoline	7.5
4.	Atlas Honda	"	Gasoline	8.6
5.	Atlas Honda	"	Gasoline	14.1
6.	Pak Hero	3-wheeler Auto Rickshwas	Gasoline	7.3
7.	Tiger Brand	70 CC motorcycle	Gasoline	14.9
8.	United Sales, US Brand	Motorcycle	Gasoline	0.18
9.	Atlas Honda	"	Gasoline	5.2
10.	Tiger Brand	3-wheeler, Rickshaw	CNG	0.1 3
11.	Saggar Engg.	3-wheeler, Rickshaw	Gasoline	16.1
12.	Pak Asia	3-wheeler, Rickshaw	CNG	0.1 1
13.	Star Asia	3-wheeler, Rickshaw	CNG	0.13
14.	Master Brand	Motorcycle	Gasoline	5.2
15.	Toyota	Car	Diesel	60.2
16.	Nissan	"	Diesel	65.0
17.	Royal Star	"	Gasoline	12.4
18.	New Asia	"	Gasoline	0.17
19.	Atlas Honda	"	Gasoline	8.3
20.	Ravi Brand	"	Gasoline	7.5
21.	Pak Asia	3-wheeler, Rickshaw	Gasoline	9.4
22.	Pak Hero	3-wheeler, Rickshaw	Gasoline	0.16
23.	Super Asia	Motorcycle	Gasoline	5.3
24.	Tiger Asia	"	Gasoline	7.2
25.	Toyo International	"	Gasoline	8.6
26.	Geo	"	Gasoline	0.2
27.	Star Asia	"	Gasoline	0.3
28.	Leader	"	Gasoline	5.4
29.	Cultus Honda	Car	Diesel	30.9
30.	Mitsubishi	Car	Gasoline	21.6
31.	Alto	"	Diesel	50.5
32.	Suzuki	"	Diesel	20.5
33.	Sunny	"	CNG	0.10

Analysis and measurements of air pollutants is carried out by different methodologies. Four general methods of analysis of gaseous pollutants are currently in use. These are (1) absorption in a liquid (2) adsorption on a solid surface, (3) condensation to a liquid and (4) conversion into a less polluting or non-polluting gas. However the information of accurately selection of methods and control equipment is necessary.

In this study exhaust gas analyzer (Delta 1600 S-MRU Germany) was used to carry out the measurement of NOx. A fuel cell sensor provides an electrical response that is proportional to the concentration of the sample gas (NOx) in exhaust. The principle is based on a non-dispersive infrared

technology, NDIR and background gaseous concentration; the apparatus is self calibrated which have microprocessor and controlled measurements. Selection of samples such as motorcycles, rickshaws, cars were carried out randomly from a large population, which the industries have. All measurements were carried out at idling state [15].

Conclusions

As the world's population increases, it will become increasingly important to have an adequate number of well-trained professionals engaged in air pollution control. Air pollution control is more likely to have a higher priority for person or a community at this time. The long-term objective of air pollution control is to allow the worlds population to meet all its needs for energy, goods, and services without sullying the air supply. Once the control system is in place, its operation and maintenance become a major concern. Considerable amount of research work is going along the following directions in terms of control techniques for limiting pollutant formation and emission at the source fall into three classes:

1. Modification of the basic process to result in "cleaner" operation
2. Substitution of alternative cleaner burning fuels in combustion processes.
3. Cleaning of the effluent gases before release into the atmosphere.

The particular techniques chosen depends on the pollutant involved the process responsible for pollutant formation, and the required degree of control. For example here use of natural gas instead gasoline and diesel and switching of two stroke engine to four stroke engine results in enormous reduction of NOx emissions as represented in Table-1 and 2 *i.e.* CNG (Compressed Natural Gas) fuel is most environmental friendly as compared to gasoline and diesel. Summarizing burning of CNG produces a large amount of water leased amount of certain nitrogen oxide ($NOx = NO + NO_2$) and almost no CO, or SO_2 and no ash.

It was observed that the fuel and energy efficiency is maximized in four-stroke engine as compared to two stroke engines. Two stroke engine produce more pollution as mobil oil is used for ignition and lubrication purposes, that cause oily smoke and smell, similarly use of oil in two stroke engines is more expensive yielding fewer miles per gallon: While four strokes is more fuel and energy efficient causing no smoke and smell and require less repair. There is no alternative of four-stroke engine and increased sale of it in the market. Making it more environmental friendly with negligible emissions of NOx.

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