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IMPACT OF AUTO-EXHAUST ON THE ENVIRONMENT: A CASE STUDY OF DHAKA CITY

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Abstract—This study is focused on the measurement and analysis of the emission levels of different vehicles and their comparison with standards. Contribution of auto-exhaust on the total air pollution of Dhaka city was also studied. The study has revealed that automobiles are the principal contributors of SO_x, NO_x, CO and hydrocarbon emissions in Dhaka city and the emission level of the vehicles playing over Dhaka city is alarming. The concentrations of suspended particulate matters, CO, SO_x and NO_x in the ambient air exceed the standard values set by the Department of Environment of Bangladesh at several points of heavy traffic congestion. Therefore, immediate actions should be undertaken to improve the air quality of Dhaka city. Some recommendations for air pollution control in Dhaka city are also incorporated in the paper.

Keywords*: Air pollution; Auto-exhaust.*

INTRODUCTION

The atmosphere, which makes up the largest fraction of the biosphere, is a dynamic system that continuously absorbs a wide range of solids, liquids, and gases from both natural and man-made sources. These substances travel through air, disperse, and react with one another and with other substances both physically and chemically and eventually find their way into a depository such as the ocean, or to a receptor such as man.

Air pollution may be defined as any atmospheric condition in which substances are present at concentrations high enough above their normal ambient levels to produce a measurable effect on man, animals, vegetation, or materials. The rare meteorological events happened in the different countries of the world [Rao and Rao, 1996] made it clear that air pollutants are hazardous to human health and at high enough concentrations can even cause death.

Concerns over air pollution ultimately led to the initiation of National Ambient Air Quality Standards for the following six criteria pollutants in the USA in the early 1970s:

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Sulfur dioxide (SO_2)
Carbon monoxide (CO)
Nitrogen dioxide (NO_2)
Ozone (O_3)
Suspended particulate matter (SPM)
Non-methane hydrocarbons

In the late 1970s Environmental Protection Agency (EPA) of USA added lead (Pb) to the list. Particulate matter with an aerodynamic diameter of less than or equal to 10 μm (PM_{10}) was added to the list in 1987.

In recent years policymakers in metropolitan areas throughout the developing world have been working to monitor and mitigate worsening levels of air pollution.

Dhaka, the capital of Bangladesh, is one of the largest cities of the world, with a population of about 10 million. It is expanding very rapidly. Although the number of motor vehicles per thousand people in Dhaka city is still low compared to other capital cities of developing countries; very high population, poorly maintained motor vehicles and severe traffic congestion are causing high level of pollution here. With the expected economic growth, the consequent increase in the number of motor vehicles together with this high population level, the air pollution situation of this city will deteriorate further in future.

In the winter of 1996-97, air pollution of Dhaka city became the severest when lead in the air was reported higher than in the atmosphere of any other place of the world [Ahmed, 1997; Khaliquzzaman *et al*, 1998; Ahsanuzzaman, 1996]. The amount of other harmful elements like the suspended particulate matters (SPM), sulfur dioxide and the oxides of nitrogen were found to be exceeding their acceptable levels. Since 1996, the situation is deteriorating day by day.

Epidemiological studies show that air pollution in developing countries accounts for tens of thousands of excess deaths and billions of dollars of lost productivity every year [Faiz *et al*, 1996].

Concern over air pollution rate of Dhaka city ultimately led to the initiation of National Ambient Air Quality Standards for four criteria of pollutants in Bangladesh in 1997. The four criteria pollutants were:

Suspended particulate matter (SPM)
Sulfur dioxide (SO_2)
Carbon monoxide (CO)
Nitrogen dioxide (NO_2)

This study focuses on how auto-exhaust impacts on the air pollution in Dhaka city. The study also includes the steps to be taken to combat air pollution due to vehicular exhaust.

EXPERIMENTAL

Methods of Measurement

In this study, the auto-exhaust is analyzed with two different kinds of equipment and techniques. The pollutants emitted from the sample vehicles were analyzed with auto-exhaust analyzer (Indian origin) at BRTA, Dhaka during their fitness test. Auto-exhaust analyzer was used to determine the concentration of CO and HC in the exhaust. Gastec technique (Japanese origin) was used for CO and HC concentration determination from running vehicles. Ambient air quality was assessed by the continuous environmental monitoring unit (USA origin) and high volume air sampler (APM 415 Environtech, India).

RESULTS AND DISCUSSIONS

The present paper may be divided into four sections such as experimental, results, discussions and recommendations for air pollution control. Average values of emission from different vehicles are shown in Tables 1 and 2.

Table 1: Average test results of vehicular exhaust obtained in 1999

Type of vehicle	Different pollutants		Different standards *
	CO, %	HC, ppm	
Motor car	3.46	712	Bangladesh (1997) CO = 4% HC = 180 ppm
Moving motor car	5.46	1067	
Moving Tempo	9.1	1925	USA Standard (1970) CO = 1% HC = 180 ppm
Micro bus	4.69	832	
Bus	3.75	920	
Motor cycle	3.83	588	

* Guide to the Environmental Conservation Act 1995 and Rules, 1997, Prepared by Bangladesh Centre for Advanced Studies, 1999.

Table 2: Average test results of vehicular exhaust obtained in 2000

Type	Pollutants	
	CO, %	HC, ppm
Toyota Corolla	4.69	647
New model car (Mark-II, Toyota Cresta, Super Saloon etc.)	1.87	393
Honda (Car)	4.12	550
Toyota Starlet and Publica	6.78	857
Hyundai (Car)	6.83	753
Toyota Microbus (HIACE)	6.04	637
Mitsubishi and Nissan (Car)	7.34	1275
Bus	7.35	1500
Jeep (Pajero, Land cruiser, Nissan Patrol, Land rover)	4.96	1893
Baby Taxi	6.91	3165
Motor cycle (Honda, Yamaha, Honda RX, Honda XL, Bajaj)	6.32	708

On the basis of the collected and presented data the following conclusions may be drawn:

i) The old model vehicles generally cause more pollution.

ii) Not all the old vehicles have the same trend on pollution level. This is because other factors such as maintenance, fuel quality, engine condition and the level of education of users have got large effect on the composition of the auto-exhaust.

iii) The two–stroke engine emits more CO than four-stroke engine. In a two–stroke engine, a mixture of lubricating oil and fuel is used. For this reason, the burning of fuel is incomplete, thereby producing maximum amount of CO and unburned hydrocarbons.

iv) The new model cars generally emit less pollutant because of the fact that most of the new model cars are based on electronic fuel injection (EFI) or programmable fuel injection (PGFI) system which control the air fuel ratio properly.

v) Generally, the emission of pollutants from diesel engines is higher than petrol engines.

vi) Comparison of the concentration of pollutants of the auto-exhaust with standards reveals that the average values obtained from our sample vehicles are significantly above the standard values.

Alam and others have observed in their study that automobiles were the principal contributors of SO_x, NO_x and CO emission in the city [Alam *et al.*, 2000]. Here the category, automobile includes all types of passenger car as well as jeeps and microbuses. The contributions from bus and truck are significant in the case of SO_x and NO_x emission (Fig. 1).

The ambient air quality of Dhaka city with respect to CO, CO_2, SO_2, NO_x, and hydrocarbon is summarized in Table 3 while Table 4 shows the values of suspended particulate matter (SPM). A comparison between previous data and data obtained during this study has been presented in Tables 4 and 5. The standard limits of air pollutants set by the Department of Environment of the Government of Bangladesh and the USA Government are also included in the above mentioned Tables. It is apparent from the experimental values that in terms of suspended particulate matter the situation is rather alarming.

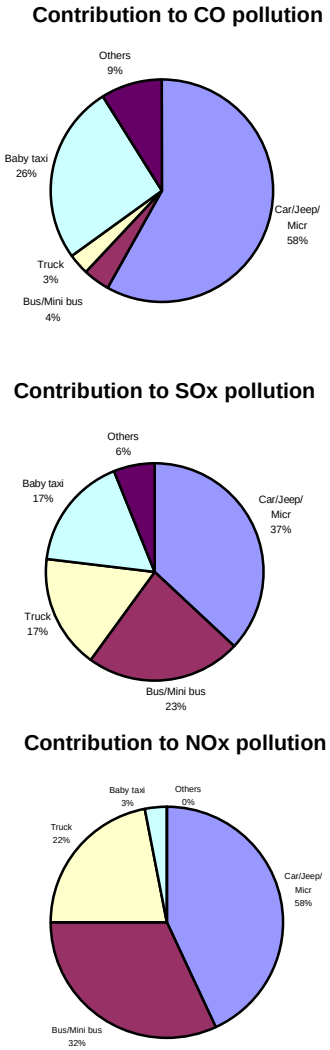

Fig. 1: Contribution of CO, SOx and NOx to air pollution from different types of vehicles

The main contributors for SPM in Dhaka city air are:

- Vehicular exhaust (specially diesel based engines and 2–stroke engines of 3–wheelers)
- Solid waste
- Road digging round the year
- Construction work
- Stack exhaust from brickfields and industries
- Saw mills and foundries
- Food processing industries
- Other small industries

Most of SO_2 in the ambient Dhaka air originates from the sulfur present in Diesel (about 1% by mass). The concentration of SPM, CO, SO_2, and NO_x in the ambient air exceeds the standard values set by the Department of Environment of the Government of Bangladesh at several points of heavy traffic congestion.

Table 3: Ambient air quality of Dhaka city assessed on 5th November 2000

Area	Pollutant's Concentration (20 minute Average Value) µg/m^3				
	HC	**CO**	**NO_x**	**SO_2**	**CO_2** (ppm)
BUET Campus (10 AM)	1158	874	66	94	306
Polashi Bazar (11 AM)	1645	4125	123	120	318
BCSIR Police Box (3-4 PM)	1278	2624	130	146	331
Farmgate Police Box (5 PM)	1891	3557	144	121	315
Mohakhali Police Box (7 PM)	3280	7858	325	152	362
Mogbazar Police Box (9 PM)	7711	10094	468	146	450
NOTE: Bangladesh Standards Commercial and mixed (µg/m^3) SO_2: 100 CO: 5000 NO_x: 100 Residential and Rural (µg/m^3) SO_2: 80 CO: 2000 NO_x: 80 USA (EPA) µg/m^3 SO_2: 80; CO: 10,000; NO_x: 100; HC = 160					

Table 4: Average concentration of suspended particulate matter (SPM, µg/m^3) in air at different places in different years

Place	1990 (DOE)	1996 (*)	1998-99	1999-2000
Mohakhali	401	1429	1501	1080
Sc. Lab	---	956	1680	1143
Farmgate	---	2103	1583	1513
Motijheel	360	1026	---	974
Purana Paltan	---	1470	1114	---
Polashi	---	566	702	758
NOTE: Bangladesh Standard SPM = 400 µg/m^3				

* Shahnaz Begum, Study of Air Pollution in Dhaka City, M.Sc. Engineering Thesis, Chemical Engineering Dept., BUET, 1996.

Table 5: Comparison of present SO_2 concentration with previous one in ambient air

Area	Pollutant	Presnt study (2000), µg/m^3	DOE 1998, µg/m^3	Shahnaz (1996), µg/m^3	DOE 1990, µg/m^3
Mohakhali	SO_2	152	-	58	4
Farmgate	SO_2	121	87	24	-
Polashi	SO_2	120	-	11	-
Mohakhali	NO_x	325	-	-	9
Farmgate	NO_x	-	64	-	-

The concentration of suspended particulate matter in the ambient air varies greatly with weather condition. It has been noticed that the concentration of SPM has increased by 3 to 4 times (from 400 to 1600 µg/m^3) during the last decade (1990 – 2000), whereas the standard value is 400 µg/m^3.

Table 6: Average concentrations of CO, NO_2 and SO_2 at roadside of Dhaka city [Alam *et al.*, 1999]

Location	Concentration of Pollutants µg/m^3		
	CO	**NO_2**	**SO_2**
Science Lab.	79900	500	900
Zigatola	43000	300	500
Pantho Path	85100	500	900
Azampur Uttara	22900	300	800
Mohakhali	69300	500	1200
Shahbagh	38100	300	500
Gulistan	33000	500	800
Jatrabari	67000	500	1300
Mirpur	29200	400	700
NOTE: WHO Standard value (1 hour), µg/m^3 CO = 30000 SO_2 = 350 NO_2 = 400			

The concentration level of NO_x and SO_2 were around the standard values in 1996. But in the year 2000, it is

found that the values have exceeded the standard ambient concentration, which is also very much alarming for the people of Dhaka city (Tables 3-5).

The standard concentration of CO is 5000 $\mu g/m^3$. It has been observed that in any busy area of Dhaka city, the concentration level is 1.5–2 times higher than the limiting value (Table 3).

The road users frequently complain about bad smell, eye and skin irritation, headache and breathing problem. This may be caused by severe air pollution at the roadside of the city. As the commuting time for an average individual is about two hours (both ways), the high level of pollution may cause severe health problems. Alam and others have conducted a study to evaluate the roadside environment of Dhaka city [Alam *et al*., 1999]. From this study, it can be concluded that at more than seventy- percent locations, the roadside air environment is severely polluted and the rest of the locations are highly polluted. This environmental condition has very serious implications for the health of the inhabitants of the city, particularly the commuters and roadside shopkeepers (Table 6).

The recently assessed air quality of Dhaka city has revealed that immediate actions should be undertaken to improve the air quality.

RECOMMENDATIONS FOR AIR POLLUTION CONTROL IN DHAKA CITY

- Vehicular emission can be reduced substantially through appropriate engine design, control strategies and maintenance services.

- 3–wheelers with 2–stroke engines using a blend of petrol and lubricating oil in the fuel lank is to be phased out gradually. Existing 3 - wheelers should use gas-based fuel instead of petrol and lubricating oil blend.

- The proposed new refinery may be so designed that it produces low sulfur diesel and unleaded petrol.

- Catalytic reforming and hydrofining processes are to be installed in ERL so that it can produce unleaded gasoline and low sulfur diesel.

- Catalytic converter, efficient filters, and adsorbers can be used for vehicular exhaust gas treatment

- Appropriate transportation planning is to be adopted to introduce efficient mass transit.

- Rickshaws are to be gradually phased out from the main roads. They may be allowed to operate in lanes and by-lanes only. The reason for this is that they slow down the traffic, thus causing higher pollution.

- Better traffic control and management with fly-overs, one-way streets, multistoried parking, metered parking etc. are to be introduced.

- DOE and BRTA should enforce their regulations strictly.

- Efficient solid waste management system to be introduced.

- Coordination between DESA, WASA and T&T is needed to reduce the concentration of suspended particulate matter in the air of Dhaka city.

- Ensuring effectiveness of control programs through ambient air quality monitoring.

- The engines of the existing petroleum fuel based vehicles are to be modified so that they can use gas based fuel.

- Social awareness about the consequences of environmental degradation to be created through mass media such as TV, radio, and newspaper.

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