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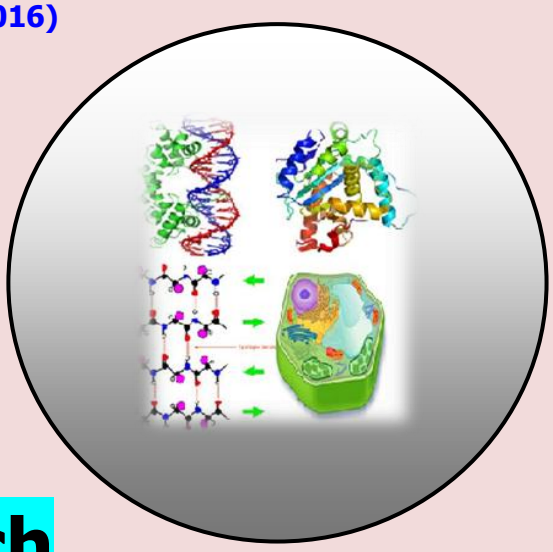

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RESEARCH PAPER

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Study of Level of Vehicular Exhaust Emissions by Urban Traffic: A Statistical Approach

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ABSTRACT

With the increasing urbanization and industrialization, the transport demand has increased many folds since the last few decades. Motor vehicles account for 60%-70% of the air pollution in an urban environment and are responsible for the emission of gases like CO_2, NO_x, HC, CO and unburnt particles. These are the major sources of air pollution and global warming that is responsible for devastating climate change. Present field survey was conducted at randomly selected pollution test centres installed at the petrol pumps to assess the number of vehicles getting "Pollution Under Control" (PUC) certificates and the emission levels of various pollutants in the vehicular exhausts of the tested vehicles run on the petrol/diesel. The study indicated that the number of three-wheelers (autorickshaws) and heavy duty vehicles (buses, trucks and canters) getting PUC certificate was significantly less as compared to two-wheelers (scooters, bikes and mopeds) and four-wheelers (cars) although visual records reveal high level emissions of pollutants from three-wheelers and heavy duty vehicles. Not even a single vehicle failed PUC test which clearly points towards inappropriate testing methods and standards that failed to detect even the gross polluters.
Keywords: Vehicles, Emissions, PUC, Three-wheelers and Heavy duty vehicles.

INTRODUCTION

Air pollution is one of the most threatening problems in the twentieth century which is the result of rapid development in different spheres and consequent modern human life styles. It is no longer a problem of urban areas but it has prevaded even to remote rural areas. Motor vehicles account for 60%-70% of the air pollution in an urban environment (Singh *et al*., 1995). Vehicular pollution is much greater than that caused by the emissions of dust and poisonous gases by factories. Vehicles account for major fraction of the total CO_2, 25%-30% of NOx, 50% of hydrocarbons (HC) and 60% of carbon monoxide (CO) and unburnt particles which are the major sources of air pollution responsible for devastating climate change. Almost a third of world's commercial energy is used for transport and this sector contributes 30% of the global warming (Singh *et al*., 1995).

Vehicles have been categorized into 3 types:
1) Passenger cars powered by four-stroke gasoline or diesel engines.
2) Motorcycles, scooters and auto rickshaws driven by either two-stroke or four-stroke gasoline or diesel engines.
3) Large buses and trucks driven by four-stroke diesel engines (Rao and Rao, 1997).
Accordingly, nearly 70% of the vehicles are two and three-wheelers which are mostly two-stroke engine driven while petrol driven vehicles with four-stroke engines constitute only 14% and the diesel driven vehicles make up 8% of the total (Tiwari, 2007). Vehicles discharge emissions directly into the breathing zone, thus, motor vehicles are the primary cause for deteriorating air quality in urban areas as compared to other sources (Azad and Kitada, 1988; Fulekar, 1999 and Sarin *et al*., 1999). The harmful substances released by vehicle exhaust leads to a number of diseases like bronchitis, pneumonia, cardiovascular effects, influenza etc. and may even cause death also. Boralkar *et al*. (1992), Joshi (1998) and Tripathy and Dwivedi (2002) reported that pollutants beyond a certain limit are very harmful to our public health, air quality and climate. Air quality has been monitored from time to time by various researchers tp study air pollution problems arising from vehicles so that proper planning for the future can be done (Siva Coumar, 2000, Behera et al., 2005, Maurya, 2005). Several steps have been recommended by the Central Pollution Control Board (CPCB) to keep a close watch on the exhaust emissions released by the increasing number of vehicles. To combat this, government has introduced lead free petrol and diesel which release low sulphur dioxide concentrations in the atmosphere. The privately operated pollution test centres have also been set up by the Central Government and State Transport Department since 1992 under "Pollution under Control" (PUC) certificate scheme which help the govt. to assess the levels of harmful air pollutants emitted by these vehicles and maintain the emission standards from the vehicle exhausts in different districts of the state. These test centres issue PUC certificates under the Central Motor Vehicles Act which are valid for only six months to the vehicle owners after examining the concentration level of the exhaust gases of their vehicles. The minimum qualification for running these centres should be either matric or higher secondary or an I.I.T certificate holder. Keeping in view, the causes and effects of air pollution, the present research has been done by surveying the records maintained by the test centres to assess the number of vehicles getting the PUC certificate and the emission levels of various pollutants in the vehicular exhaust of the tested vehicles run on the petrol/diesel.

MATERIALS AND METHODS

Present study has been conducted at randomly selected four pollution test centres installed at petrol pumps located in district Kaithal and Kurukshetra in Haryana (Fig. 1). Kaithal district of Haryana is geographically located between latitude $29^{c}81'$N and longitude $76^{c}40'$E. The total area of Kaithal district is 2,389 sq. kms. Kurukshetra district of Haryana is located in North-Eastern part of the state, lying between $29^{c}98'$N latitude and $76^{c}82'$E longitude with an area of 1,530 sq. kms. In these two districts, four pollution test centres installed at the petrol pumps (Table 1) were randomly selected for conducting the present study. Such privately operated pollution test centres set up by the Central Government and State Transport Department since 1992 under 'Pollution Under Control' certificate scheme to help the Govt. to assess the levels of harmful air pollutants and maintain the emission standards from the vehicle exhausts in different districts of the state.

Sampling Site 1

It is located in the heart of the city, Kurukshetra, near the local bus stand. The area around is categorized as residential cum commercial. This site is located on the petrol pump namely, M/S Surender Singh and Company with the distributorship of Indian Oil. This test centre only provides testing facility for two-wheelers/four-wheelers running on petrol (Photos 1-2).

Sampling Site 2

It is located outside Kurukshetra city, sprawled by Haryana Urban Development Area premises. This site is located on the petrol pump namely, M/S Shree Fuels and Motors with the distributorship of Bharat Petroleum. This test centre provides testing facility for two-wheelers/four- wheelers running on petrol (Photos 3-4).

Sampling Site 3

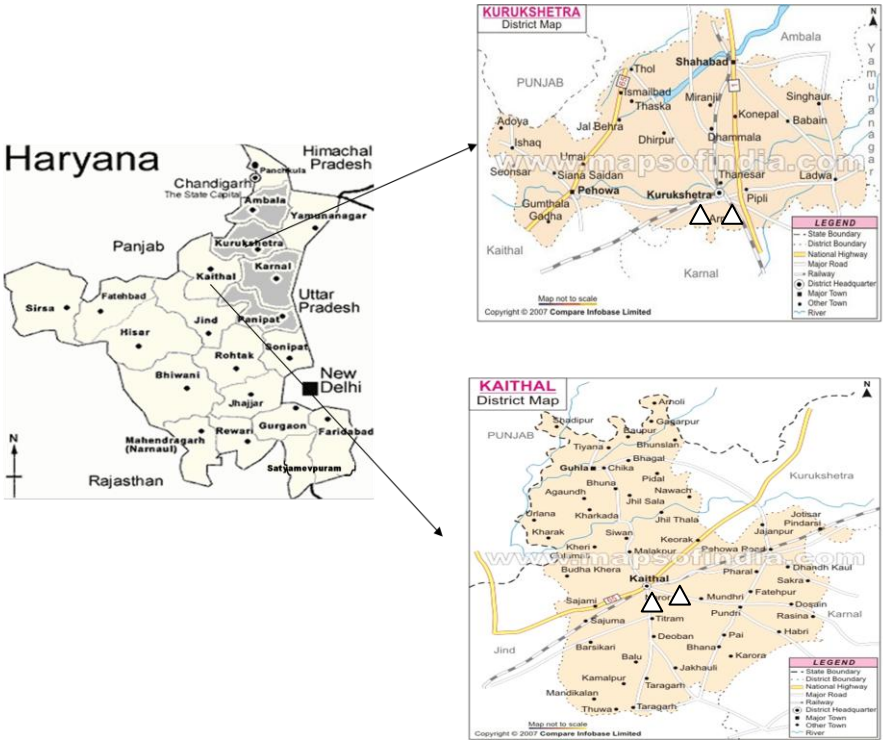
It is located inside Kaithal city, near the bus stand. The area around is categorized as residential cum commercial. This site is located on the petrol pump namely, Tara Chand Oudh Bihari with the distributorship of Indian Oil. This test centre provides testing facility for both petrol and diesel vehicles.

Sampling Site 4

It is located outside the Kurukshetra city, on G.T. Road, 5 kms. from Pipli bus stand towards Ambala. It is a major traffic intersection, commercial area, sampling site. This site is located on the petrol pump namely, M/S Sita Ram Tushar Chand with the distributorship of Hindustan Petroleum. This test centre provides testing facility for both petrol and diesel vehicles.

METHODOLOGY

Survey of the records maintained by the test centres: In all, four test centres were randomly selected in two districts namely, Kaithal and Kurukshetra of Haryana (Table 1). The survey of the records from these primary data sources was done with respect to assess the number of vehicles getting PUC certificate and the emission levels of various pollutants in the vehicular exhaust of the tested vehicles run on the petrol/diesel (Photos 5-7). The recorded data was later on analyzed to draw the meaningful conclusion. The relevant data were statistically analyzed using student's t-test.



△△ **Studied sampling site**

Figure 1. Map of Haryana depicting the study area.

Photos 1-2. Studied sample site and pollution test centre installed at the petrol pump in district Kurukshetra (Sampling site-1)

Photos 3-4. Site showing the location of petrol pump in district Kurukshetra (Sampling site-2).

Photos 5-7. Pollution test machines installed at the pollution test centres to check the emission levels of various gases from vehicle exhausts.

RESULTS AND DISCUSSION

Field survey was conducted in the randomly selected four pollution test centres installed at respective petrol pumps in districts Kaithal and Kurukshetra for continuously six months study period from January 2007 to June 2007. The number of vehicles getting the 'Pollution Under Control' certificate and the records related to emission levels of various pollutants was collected from computerized primary data sources in each randomly selected test centre. The results of the field survey are presented in Table 2. In all, data pertaining to 458 two-wheelers (scooters, bikes and mopeds), 15 three-wheelers (auto rickshaws), 203 four-wheelers (cars) and 39 heavy duty vehicles (buses, trucks and canters) was collected at four randomly selected test centres in two districts of Haryana. The results revealed that the number of petrol vehicles getting the PUC certificate was significantly more ($P > 0.05$, t- test) as compared to the diesel vehicles, *i.e.*, auto rickshaws and heavy duty vehicles such as buses, trucks and canters etc. (Table 2). Periodic information collected for six month study period indicated a variable number of two-wheelers, three-wheelers, four-wheelers and heavy duty vehicles getting PUC certificate (Fig. 2). The survey clearly pointed that the number of three wheelers (autorickshaws) and heavy duty vehicles (buses, trucks and canters) getting PUC certificate was significantly less ($P < 0.05$, student's 't' test) as compared to two-wheelers (scooters, bikes and mopeds) and four-wheelers, *i.e,.* cars (Fig. 2). Among the petrol run two-wheelers, maximum number of bikes got the PUC certificate as compared to the scooters and mopeds (Table 2). As far as Pre Bharat Stage/ Bharat Stage four-wheelers are concerned, more Bharat Stage vehicles got the PUC certificate as compared to the Pre Bharat Stage vehicles at all the sampling sites (Table 2). The possible reason for this variation is that Pre Bharat Stage (PBS) vehicles have been manufactured before the year 2000, whereas, Bharat Stage (BS) vehicles have been manufactured after the year 2000. The data regarding the CO and HC exhausts from the vehicles (getting the PUC certificate) was also recorded regularly for six months from the pollution test centres installed at the respective petrol pumps. The recorded data pertaining to the exhaust emission range of different vehicles for six month study period have been presented in the Table 2. The study revealed that the petrol two-wheeler scooter vehicles had the emissions range of CO/HC from 0.27 ppm to 2.7 ppm; bikes had the emissions range from 0.2 ppm to 3.1 ppm and the mopeds had the emissions ranging from 0.3 ppm to 2.7 ppm. However, four- wheeler petrol vehicles (cars) of Pre-Bharat Stage and Bharat Stage had the emissions range of CO exhausts from 0.13 ppm to 3.17 ppm and 0.01ppm to 2.5 ppm respectively. Similarly, the emissions range of HC exhausts of Pre-Bharat Stage and Bharat Stage vehicles varied from 830 ppm to 3267 ppm and 110 ppm to 1256 ppm respectively (Table 2).
The data revealed that the Bharat Stage vehicles emitted less exhausts of CO and HC as compared to the Pre-Bharat Stage vehicles.

This might be due to the fact that the Bharat Stage vehicles are fitted with a catalytic converter which helps in better combustion of the fuel releasing less concentration levels of harmful exhausts as compared to Pre-Bharat Stage vehicles. The state government of Delhi inacted the law for the launch of Bharat Stage vehicles in the large numbers from the year 2000 (INAV, 2000) and to replace all Pre-Bharat Stage vehicles with the catalytic converter fitted vehicles by the year 2005. As far as diesel vehicles were concerned, three-wheeler (auto rickshaws) had the emissions range of smoke (Hartridge Smoke Unit) and unburnt particles from 29.4% to 52.8%. Diesel cars had the emissions range of HSU from 27.9% to 62.16% and heavy duty vehicles had the emissions range of HSU from 33.71% to 58.41% respectively (Table 2). The results clearly pointed that very few three-wheeler auto rickshaws and heavy duty vehicles got the PUC certificates during the six months study period from four randomly selected test centres as compared to two-wheelers and four- wheelers although visual records reveal high level emissions of pollutants from three wheelers and heavy duty vehicles. These findings indicate that government must take adequate steps towards the compulsory periodic issue of PUC certificates to these three-wheelers and heavy-duty vehicles. Also, it was noted that not even a single three-wheeler and heavy duty vehicle failed the PUC test. This might be due to the reason that either these vehicles got the pre-service of the vehicles done before getting the PUC certificate or got the engineered changes in the emission levels at the time of PUC testing at the test centres. The data also supports the reports of Centre of Science and Environment (Anonymous, 2003) according to which the average failure rate during PUC testing was less than 10 per cent. Accordingly, not a single diesel vehicle used to fail the PUC test, which was entirely the result of inappropriate testing methods and standards that failed to detect even the gross polluters (Anonymous, 2003). Earlier Trivedi *et al*. (1993) observed that vehicular pollution is caused more from three-wheelers. Sawyer *et al*. (1998) also reported that the evaporative and crankcase emissions which include uncontrolled CO and NOx emissions on a fuel consumed basis were much greater from diesel mobile sources as compared to the gasoline mobile sources. Symeonidis *et al*. (2003) revealed that the HDVs pollute more than the other vehicle types as the number of passenger cars, motorcycles, HDVs and LDVs has increased. According to a report by INAV (2007) diesel cars are increasing by the rate of 17% annually which resulted in the significant increase in the air pollution and nullifying the impact of CNG programme in Delhi. During the PUC testing of the petrol engines, samples are taken in the tail pipe when the engine is idling and both unburnt HC and CO are measured. While CO level in g/Kg petrol is more or less same during transients like idling, acceleration and deceleration, the level of HC will vary drastically. Regarding the diesel vehicles, a smoke meter is used and the capacity of smoke is assessed by a light vehicle. These tests are done when the vehicle is stationary with the warmed-up engine running and subjected to free acceleration (Murthy, 2003). According to a report by INAV (2003) PUC norms are not applied fully to the diesel vehicles, which is a major source of deadly particles in the air. The free acceleration smoke tests for diesel vehicles have very limited use in checking particulate emissions. A smoke test can catch only visibly smoking vehicles with malfunctioning engines but not the vehicles with high emissions of finer particles. Diesel vehicles are of serious concern as very few immediate emission control strategies exist for millions of diesel trucks, commercial vehicles and diesel cars on the road. Also, according to a report by Center of Science and Environment there is weak enforcement and manipulation on the part of PUC booth operators so such PUC checks have failed to meet the targets with a compliance level of 20%. Accordingly, PUC centres are only meant for making money. Legislative measures for control of automobile air pollution requires a careful review demanding that the PUC test procedure and norms for all types of vehicles should be needed to revise. There is a need for implementing the advanced vehicle inspection system and centralized testing facilities, only a credible inspection programme can win public support, cut in-use emissions and even exert pressure on the industries and refineries to improve engine technologies and fuel quality (INAV, 2003).

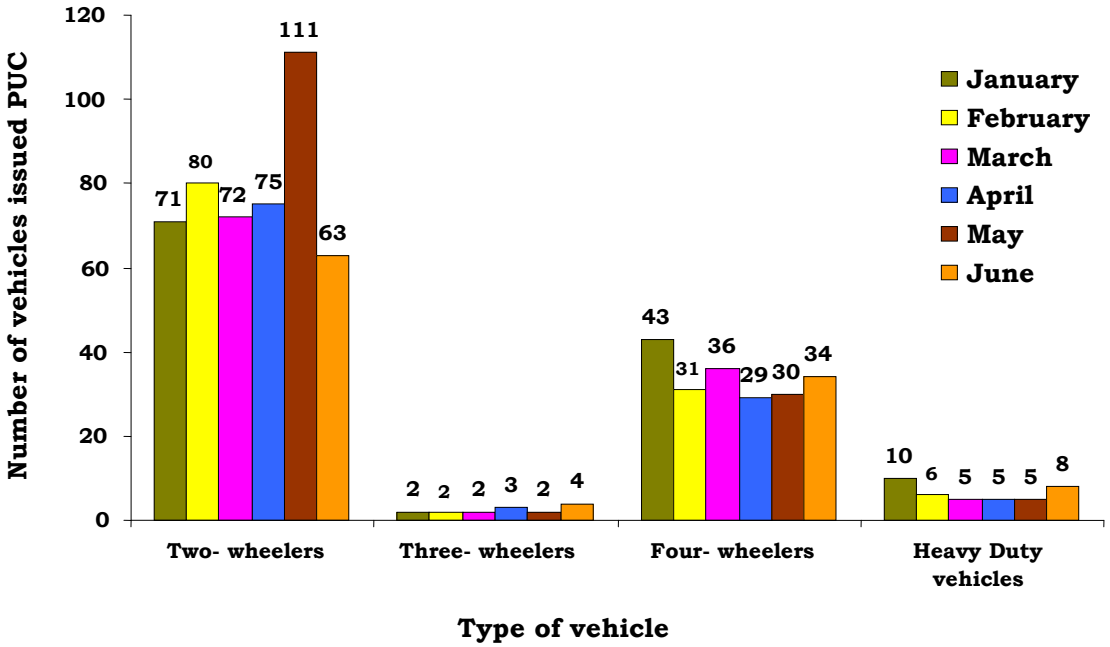


Figure 2. Number of vehicles issued PUC certificate and emission levels of selected exhaust gases at various sampling sites during the study period.

Table 1. Description and Classification of Sampling Sites.

Sampling Site	Location	Area	Authorized Petrol Pump	Distributorship	Pollution Test Machine Petrol Diesel	
Near Bus stand, Kurukshetra	Centre of City	Commercial/ Residential	M/S Surendra Singh and Company	Indian Oil	NEPTUNE TD 2040EGA Multigas 4005	----
Pipli Road, Kurukshetra	Outside city	Residential	M/S Shree Fuels and Motors	Bharat Petroleum	INDUS PEA 202	----
Near Bus stand, Kaithal	Centre of city	Commercial/ Residential	M/S Tara Chand Oudh Bihari	Indian Oil	AVL Gas Check 2000	AVL 437 Smoke meter operating unit 4370.02
G.T. Road, Kurukshetra	Outside city	Commercial	M/S Sita Ram Tushar Chand	Hindustan Petroleum	INDUS PEA 202	INDUS OMS 101

Table 2. The number of vehicles issued PUC certificate and emission levels of selected exhaust gases at various sampling sites during the study period.

Type of vehicle		Type of fuel	Total number of vehicles issued PUC certificate	Pre-Bharat Stage/ Bharat Stage	CO (ppm)		HC (ppm)		CO/HC (ppm)	Hartridge Smoke Unit (HSU) %
					PBS	BS	PBS	BS		
Two-wheelers	Scooters	Petrol	37	-	-	-	-	-	0.27- 2.7	-
	Bikes	Petrol	385	-	-	-	-	-	0.2 - 3.1	-
	Mopeds	Petrol	36	-	-	-	-	-	0.3 – 2.7	-
Three-wheelers		Diesel	15	-	-	-	-	-	-	29.4 – 52.8
Four-wheelers		Petrol	151	59/121	0.13 - 3.7	0.01- 2.5	830- 3267	110 - 1256	-	-
		Diesel	52	31/38					27.9 – 62.16	-
Heavy duty vehicles		Diesel	39	-	-	-	-	-	-	33.71 – 58.41

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