IMPACT OF VEHICULAR EMISSION NORMS ON VEHICULAR POLLUTION LOADS IN DELHI

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ABSTRACT

The traffic is growing at rapid rate in urban areas of India and the management of traffic operations on the limited road network has become a gigantic task to the concerned authorities. It is found that on an average about 1000 vehicles are getting registered in Delhi every day. The main objective of this study is to evaluate the impact of National Auto Fuel Policy vehicular emission norms on vehicle pollution loads in Delhi. In order to achieve this, extensive traffic surveys were conducted to estimate network link flows and vintage characteristics of vehicles in Delhi. The study results shows that the policy interventions by implementing the Bharat Stage (BS)-I, BS-II and BS-III, in addition to implementing the CNG Autos, CNG buses and conversion of some of the cars into CNG have reduced the pollution loads considerably. However absence of proper travel demand management to tackle the increased travel demand has created frequent bottlenecks in the road network resulting in nullifying the benefits gained by the policy interventions. Hence it is equally important to focus on the policy measures in terms of travel demand management measures by removing the bottlenecks in the road network there by congestion reduction in addition to implementing the emissions norms.

Keywords: Traffic loads 1, Vehicular pollution loads 2, Vehicular emission norms 3, Impact evaluation 4.

INTRODUCTION

Delhi, the capital city of India is one of the most rapidly expanding mega cities and as per the Census of India (2001) it had a population of 12.7 million in 2001 (estimated to be around 16.64 million in 2007). Delhi is very rapidly growing with an average annual population growth rate of about 4.5% (India has national average growth rate of 2.1% per annum). Delhi is having total registered vehicles of more than 5.63 million in 2008 (more than 12% of India's automobile population) with the predominance of two wheelers and cars. The travel needs in Delhi are mainly met by road transport with a total road network of about 30,000 km which includes all categories of roads. The recent past transportation studies (CRRI, 1984 and CRRI, 2002) revealed that the travel demand has tremendously increased in the last three decades by more than two times in terms of per capita trip rate (vehicular) in a day from 0.45 in 1969 to about 1.0 in 2001. Further the latest transportation study (GNCTD, 2009) found that the major modes of transportation are buses, private vehicles (namely cars and two wheelers), taxis, auto rickshaws and bicycles in the order of total trips made in a day. But the trips made by car and two wheelers were increased significantly as compared to year 2001 whereas bus trips were reduced and redistributed among the other modes such as Metro, Cycle Rickshaws etc. Further the average trip lengths have increased marginally for all modes of transport over years. The increase in average trip lengths is clearly indicating that the compact city concept was gradually diminishing. Travelling longer trip lengths a day is further increasing the pressure on exiting road network and increasing vehicular emissions. In order to curb these traffic and pollution loads, many different policies were proposed. However, a proper assessment of pollution loads from vehicular traffic is an essential requisite for any policy measures to enable to propose appropriate remedial measures to control the menace of congestion and air pollution. This aspect is very aptly emphasised in the CRRI study on Urban Road Traffic and Air Pollution (URTRAP) in 2002, which deals with the quantification of the travel demand and associated pollution loads in a scientific manner and thereby enabled in evaluating the impact of the proposed National Auto Fuel Policy apart from the devising road map for its implementation (CRRI, 2002). Considering the above facts, the present study aimed at estimating quantum of travel demand in terms of Vehicles Kilometres Travelled (VKT) by each mode and quantifies the associated pollution loads in Delhi and impact of National Auto fuel policy emission norms on vehicular pollution loads in Delhi.

In next section Methodology has been explained, In section 3 data collection and analysis have been discussed with the focus on vehicular and travel characteristics. the estimation of VKT (Vehicle Kilometres Travelled) has been explained in Section 4. In Section 5, impact of National Auto Fuel Policy on air pollution of Delhi has been dealt and Section 6 ends with conclusions.

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METHODOLOGY

Keeping the objectives and resources allotted for the present study in view, it was proposed to utilise the traffic database generated by URTRAP study (CRRI, 2002) as the datum.

Thereafter, it has been proposed to carry out the defined scope of work based on the traffic studies carried out in the intervening period for the year 2009. The traffic studies, which are to be carried out and methodology to be adopted for the estimation of traffic and pollution loads is briefly explained in the paragraphs to follow.

In order to accurately estimate the pattern of traffic flows and spatial distribution of pollution loads from vehicles, the primary road network of the city would be identified and inspected physically through the field visits. As discussed earlier, the major arterial roads of Delhi carry more than 80% of traffic. Control points (location of survey points where traffic volumes to be measured) were selected based on previously available database on traffic volume, importance of road, adjoining land use and geographical distribution. The study methodology is presented in Figure 1, which signifies both primary and secondary data sources to be used in this study.

Different researchers like Adachi and Kawashima (1979), Okamoto et al. (1990), Singh et al. (1990), Saito (1977), Sasaki (1978) and Hammerle (1976) used different methods for estimation of pollution loads from vehicles. These methods require information on emission factors of different pollutants, hourly traffic volume of different vehicles on different types of roads, speed of vehicles and length of different roads.

The method used in this paper to predict the air pollution loads is as follows:

$$E_i = \sum_i (Veh_j D_j) e_{i,j,km} \qquad (1)$$

Where, E_i is total emission of pollutant *i* (g/day), Veh_j is the number of vehicles of type *j*, D_j is distance traveled by vehicle type *j*, $e_{i,j,km}$ is the emission factor for pollutant *i* for vehicle type *i* (g/km). For working out the quantity of criteria pollutants (i.e. CO, NO_x, HC and PM). the input files regarding quantum of travel, share of different types of vehicles and their vintage along with appropriate / corresponding emission factors (CPCB 2000) were separately created and used in the computations. The pollution loads using the above method (i.e. given in Eq. 1) as per the category of travel by vehicle type were estimated.

FIELD STUDIES

To accomplish the study objectives, the traffic data was collected at selected 24 mid-block locations, 6 intersections in addition to interview surveys conducted at 9 outer cordon points and 30 fuel stations/ parking areas spread over the city as shown in Figure 2 . The traffic surveys at mid-blocks reveals that the maximum peak hour traffic was observed on I. T. O. Barrage Bridge with 19,000 vehicles/hr (total traffic about 1.86 lakh vehicles for 12 hours) and on Lala Lajpat Rai Marg with about 15,000 vehicles (total traffic about 1.54 lakh vehicles for 12 hours). From the intersections counts it was observed that Ashram intersection has the maximum intersection traffic flows about 3.65 lakh vehicles for 24 hours. The outer cordon surveys revealed that the maximum traffic was observed at NH-8 Toll Plaza with about 2.28 lakh vehicles for 24 hours and minimum traffic was at Apsara border on Old G. T. Road with about 50,000 vehicles for 24 hours. It was observed from traffic composition analysis that the proportion of two wheelers has shown a downward trend in inner and middle areas whereas in the outer areas it has remained more or less same during 2002 to 2009. SMVs have shown a downward trend in inner, middle and outer areas during this period. Over all, about two times increase in the traffic was observed as compared to URTRAP study in 2002.

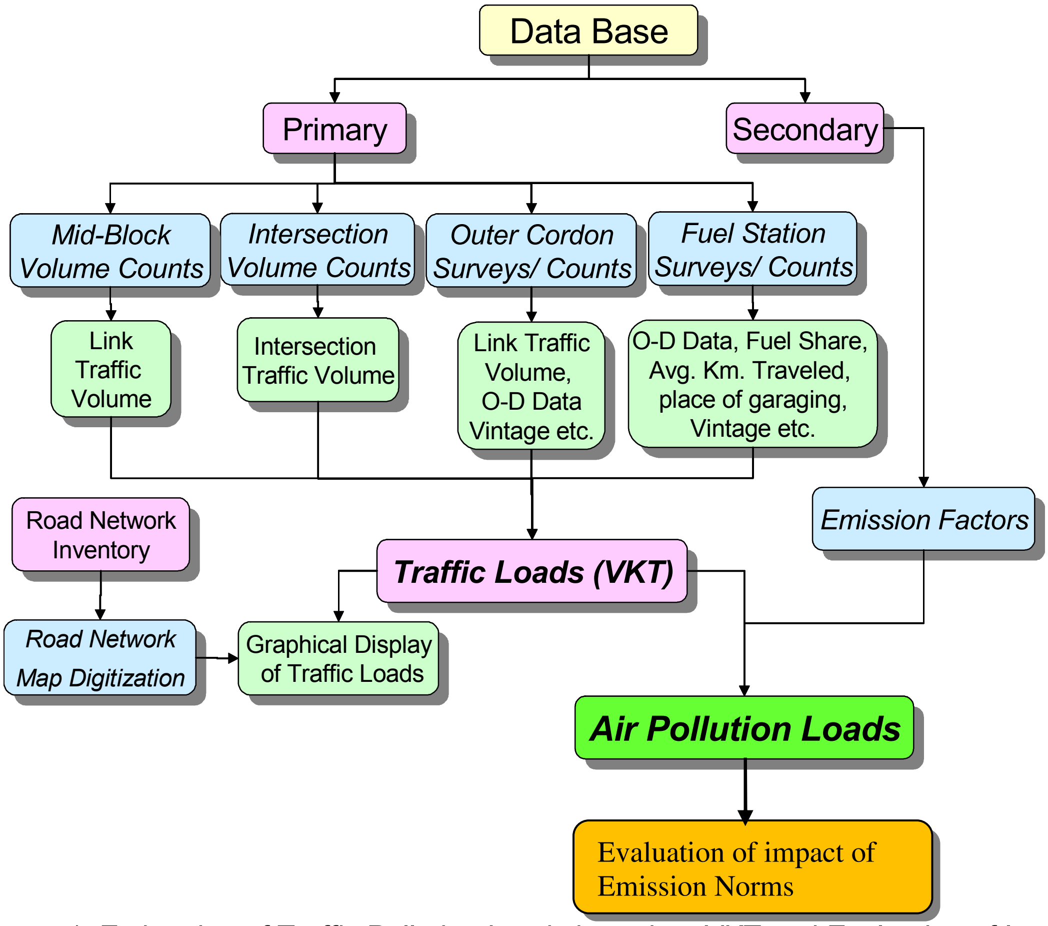


Figure 1. Estimation of Traffic Pollution Loads based on VKT and Evaluation of Impact of Emission Norms on Vehicular Pollution Loads

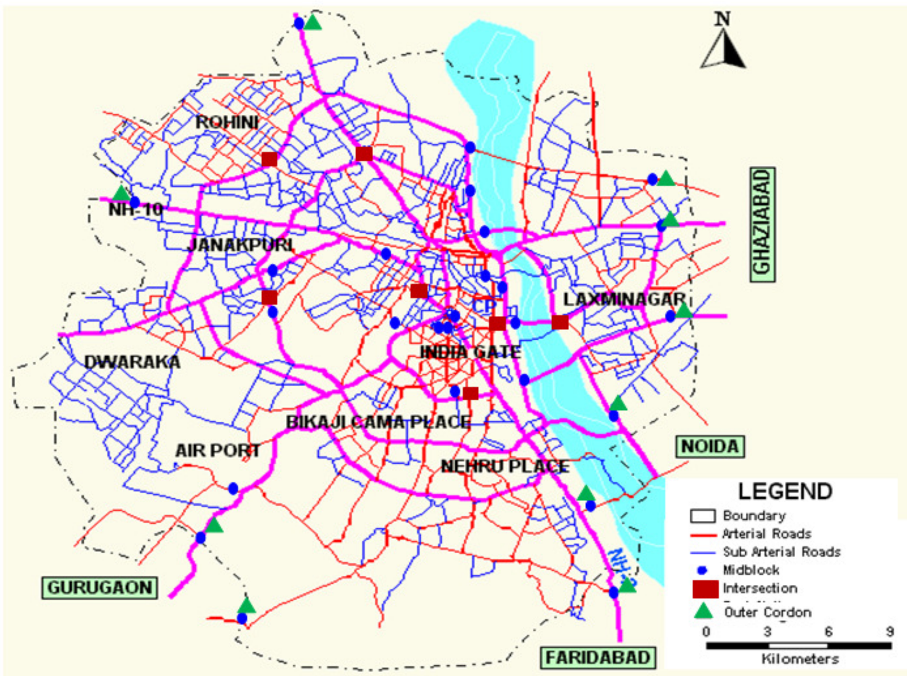


Figure 2. Locations of Different Surveys on Road Network of Delhi

Further from the commuter interview surveys at outer cordon points revealed that a total of about 4.3 lakh vehicles enter and about 4.6 lakh vehicles leave leave Delhi on an average working day. It can also be noticed that the goods traffic forms about 13 percent of the total traffic with another 3 percent of traffic is composed of slow moving vehicles like cycles, animal carts etc. Of these vehicles, about 18 percent of the goods vehicles and 8 percent of passenger vehicles are found to be passing through the city. Further, these commuter interview surveys at fuel stations/ parking areas reveals that average age of the vehicles at the cordon points is slightly younger compared to the vehicles running in the city in case of autos and buses. Furthermore it can be seen that the average age of the vehicles in Delhi is considerably lower meaning thereby that they are less polluting and more fuel-efficient. The average age of vehicles observed in Delhi is shown in Figure3.

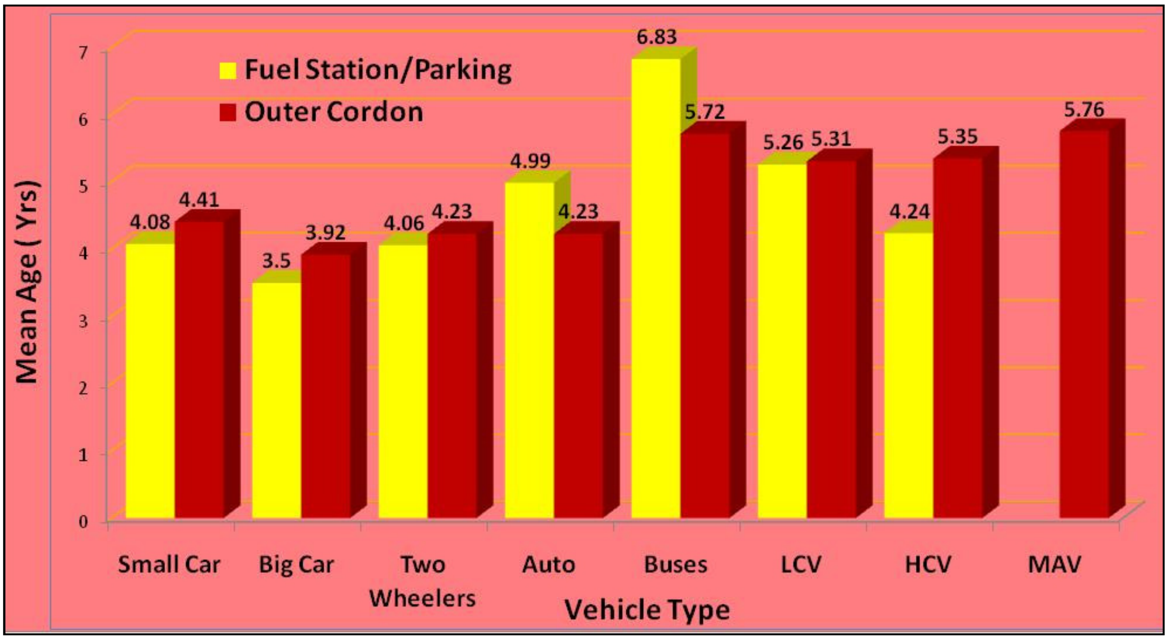


Figure 3. Average Age of Vehicles Operating in Delhi in 2009

ESTIMATION OF VKT AND POLLUTION LOADS

For the estimation of pollution loads from vehicles, the traffic loads in terms of vehicle kilometres travelled (VKT) on the entire primary road network of Delhi is first estimated. On the basis of the classified traffic counts conducted at 24 mid-block and 6 intersections, data on traffic flows on the road network of Delhi was generated. Employing this data, the traffic flows have been arrived at on the adjoining links in the neighbourhood of the count points. The traffic load is estimated as vehicle - kms by factoring the vehicular flows with the length of link. By summing the link traffic loads, the total vehicle - km travelled on the city road network was estimated and it is around 1505.6 lakh VKT. Out of this, the maximum proportion of travel (81 percent) is made by two wheelers and cars. This is followed by three wheelers constituting about 13 percent of the total VKT while buses have almost 1.8 percent and goods vehicles have share of almost 3.8 percent. As compared to the 2002 study

(792.34 lakh VKT/day) the VKT observed in the present study was almost doubled as shown in Figure 4.

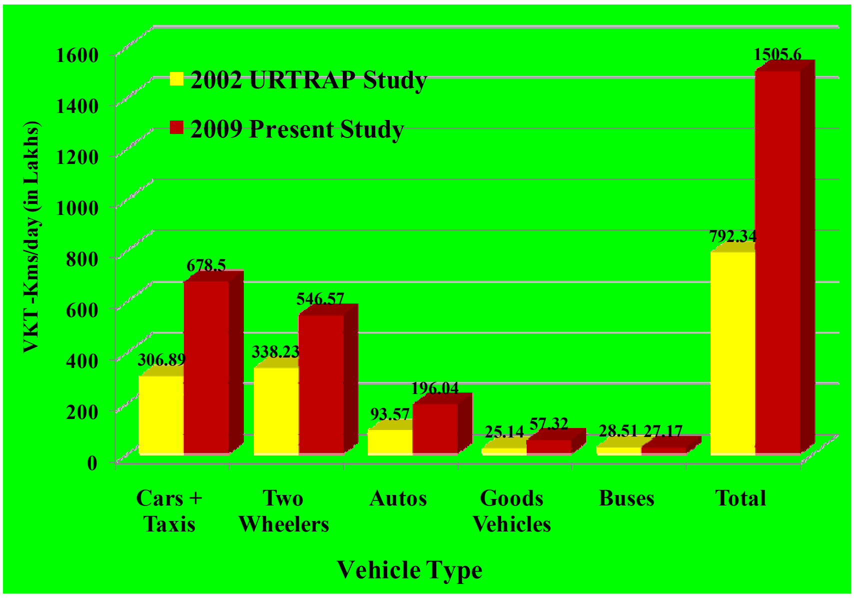


Figure 4.Estimated Daily Traffic Load on Delhi Road Network

Employing the vehicle - kilometres travelled on the city roads, total pollution load have been estimated for each of the four pollutants namely CO, HC, NO_x and PM. The estimated daily pollution loads of CO, HC, NO_x and PM from vehicles is observed in tonnes per day to be 264.55, 127.54, 82.53 and 9.81 respectively as shown in Figure 3. These pollution loads are significantly reduced compared to 2002 study and the reduction is 37 percent, 31 percent, 25 percent and 23 percent in CO, HC, NOx and PM respectively. These reductions in pollution loads can be attributed to vehicular technology in terms of emission norms implemented in the country such as BS-II and BS-III and implementation of CNG in Autos and Buses. It is to be noted here that the above pollution loads were calculated assuming the existence of typical Indian Driving Cycle (IDC) on Delhi roads by considering the CPCB emission factors (CPCB, 2000). However, as the traffic congestion is so acute for most part of the day on major arterials and sub-arterials of the city, the effect of congestion on Delhi road network was appropriately accounted by assuming that average travel times of various modes have increased by 50 percent due to congestion since the non-availability of emission factors due to congestion in our Indian conditions. Subsequently the pollution loads were estimated by increasing the loads by cars and buses with separate factor as they get affected more compared to two wheeler and autos. Goods vehicles are less affected as they travel mostly during night hours. The estimated pollution loads of CO, HC, NO_x and PM with congestion effect is around 391.5, 181.9, 126.2 and 14.1 tonnes per day respectively as shown in Figure 5.

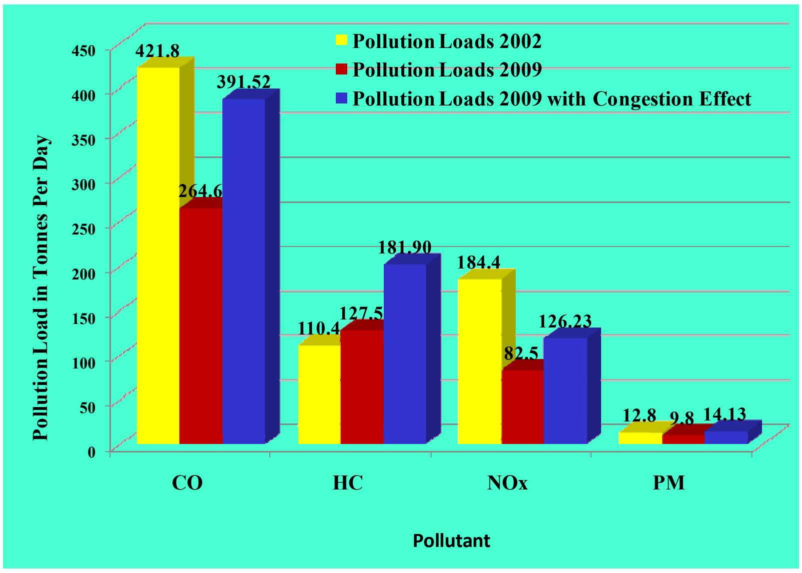


Figure 5. Comparison of Estimated Pollution Loads in Delhi

IMPACT OF NATIONAL AUTO FUEL POLICY EMISSIONS

The pollution loads are estimated for the cases of Business As Usual (BAU) 2000 and BAU 2002 and subsequently compared with present study 2009 to assess the impact of National Auto Fuel Policy emission norms. BAU 2000 and BAU 2002 options are considered because these policy norms were implemented in Delhi during this period i.e between 2000 and 2009. Figure 6 shows the BAU 2000, BAU 2002 and Present study after implementing the Auto fuel policy emission norms. From the Figure 6, it can be clearly seen that the policy norms have successfully reduced all of the pollutants compared to BAU 2000 and BAU 2002.

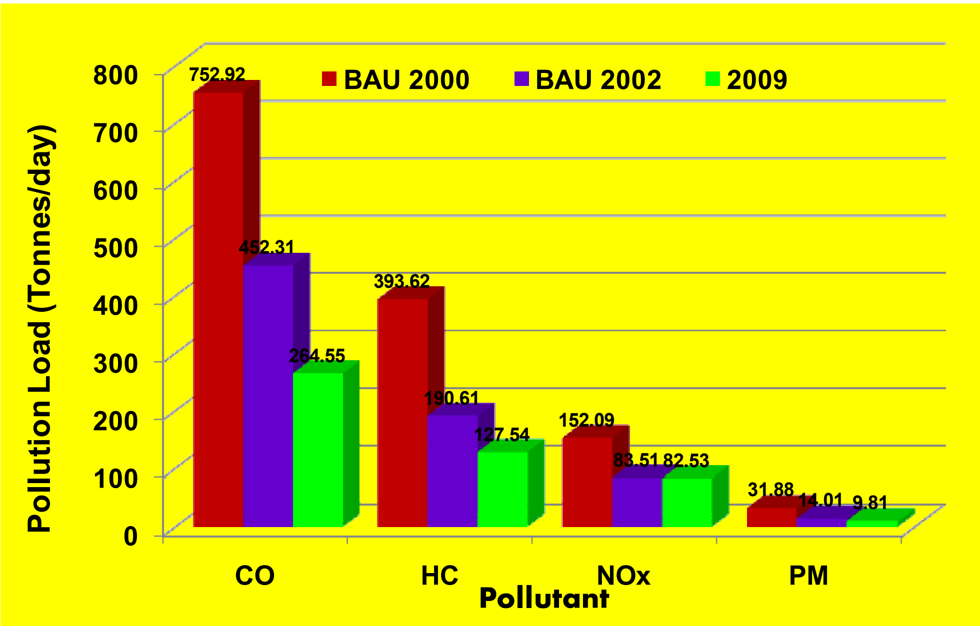
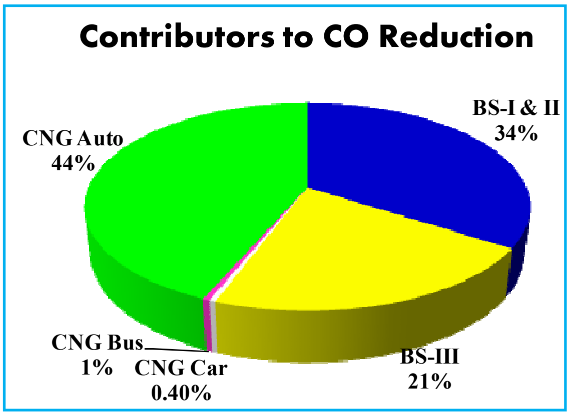


Figure 6. Impacts of Policy Interventions on Pollution Loads

Further from the analysis of results it was found that the major contributor in reducing CO is CNG Auto which reduces 44 percent followed by BS-I & II (34 percent) and BS-III (21 percent) as shown in Figure 7. CNG Bus and CNG car are very insignificant in reducing CO loads. In case of PM, the major contribution is from BS-I & II (58 percent). BS-III, CNG Auto and CNG Bus are contributed about 14 percent each as shown in Figure 7. CNG car has very insignificant contribution in reducing PM loads as they are very less in number. The other vehicle technology factors such as conversion of 2 stroke to 4 stroke engines in two wheelers and auto rickshaws and fuel quality also indirectly included under BS-I, II and III category.



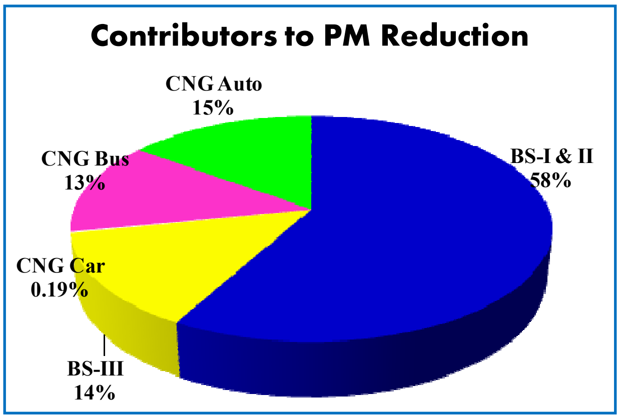


Figure 7. Contributors in Reducing CO and PM Loads

CONCLUSIONS

The study results shows that the policy interventions by implementing the Bharat Stage I, II and III, in addition to implementing the CNG Autos, CNG buses and conversion of some of the cars into CNG have reduced the pollution loads considerably. However, absence of proper travel demand management to tackle the increased travel demand has created frequent bottlenecks resulting in nullifying the benefits gained by the policy interventions. Hence it is equally important to focus on the policy measures in terms of travel demand management measures by removing the bottlenecks in the road network there by congestion reduction in addition to implementing the National Auto Fuel Policy emissions standards.
Through this study, it is recommended that National Urban Transport Policy should specify the ways and means to reduce VKT with a road map focussing on appropriate Travel Demand management Measures/polices (TDM) to achieve the desired goals inters of reducing the vehicle emissions. The National Urban Transport Policy should be in tandem with the National Auto Fuel Policy otherwise benefits gained by implementing the National Auto Fuel Policy will be nullified.

ACKNOWLEDGMENTS

Authors are thankful to Dr. Gangopadhyay, Director, CRRI, India for kind support and encouragement for allowing this paper to publication. Authors are thankful to SIAM for sponsoring the study and they are also thankful to other colleagues of CRRI for their support during the entire period of study.

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