Quantification of Pollutants from Line Source

Femina A
Assistant Professor
Department of Chemical Engineering
TKM College of engineering, Kollam, Kerala, India

Abstract

Getting good quality air for breathing is a challenging task in most of the Metropolitan Cities. Recently the schools and offices remain closed in Delhi because of heavy fog. The reason for the drastic increase in air pollution level is industrialization, increase in vehicle volume, natural and anthropological activities, etc. Large volume of vehicles in Metropolitan roads is considered as the major contributors for air pollution. The vehicle type, distance travelled, vehicle usage pattern and congested and unmaintained roads also play major roles for the evolution of various type of harmful pollutants from vehicles to the atmosphere. This is a part of work associated with Central Pollution Control Boards (CPCB) National Ambient Air Quality Monitoring (NAMP) Network project. A particular location in Chennai city is taken as background or reference site for the study. The pollution load from vehicles are calculated based on vehicle type, distance travelled, amount of fuel consumed. The emission factors and classification of vehicles based on engine capacity and vintage provided by Automotive Research Association India (ARAI), Pune. The study observed that more than 50% of the vehicles on the road are two wheelers. Petrol and Diesel vehicles are the main contributor as 84% and 81% for vehicular emission of CO and PM10 respectively.CO, SOX, NOX, HC and PM emissions /day with respect to Weekdays, Weekends, Shaastra ans Saarang are calculated separately. The total emissions per day are 2.3, 3.8 and 3.9 times more than weekend emissions for weekdays, Saarang and Shaastra respectively.
Keywords: Challenging Task, Emission Factors, Good Quality Air, National Ambient Air Quality Monitoring, Pollutants

I. INTRODUCTION

Most of the health issues reported in Indian hospitals are due to poor air and water consumption. Main reasons for atmospheric air pollution are anthropological activities, modern life style, emissions from industries and vehicles. The unbalanced air produced by the addition of foreign materials initiates unwanted photochemical reactions and causes formation of harmful products and highly reactive reaction intermediates. According to World Bank and Asian Development Bank joint study of air pollution for 20 major Asian cities between 2000 and 2003, Delhi is the most polluted city of the Asia[1]. The urban areas are considered the most polluted cities in the world in an air quality status point of view (CPCB, 2000; CPCB, 2001; TERI, 2001) [2]. Petrol and Diesel vehicles are the main contributor as 84% and 81% for vehicular emission of CO and PM10 respectively. Vehicular source is found to be the main contributor as 76%, 26% and 25% of total CO, PM10 and NOx emissions respectively[3].

Air pollution problems exists in five different scales – local (up to about 5km), urban (up to 50km), regional (50-500km), continentals (from 500 to several thousand km) and global scale extends worldwide. Worst condition of atmospheric pollution exists in a particular area when the local condition favours atmospheric inversions and the products of combustion and industrial processing are contained within the confined air mass.

The steady increase in both the number of vehicles and the distance travelled by each vehicle in each year along with other matters such as types of engines, age of vehicles, congested traffic, poor road conditions, outdated automotive technologies and traffic management systems increases the vehicular pollution [4]. The contribution as well as character of the pollutants varies according to fuel composition and their mode of application. The technology development, awareness at different levels, the legislature by enhancing laws and its effective implementation reduces the pollution to a considerable level. Besides this standards and legislations, air pollution due to vehicular emissions are increasing in alarming levels due to expansion of city, increase in vehicle volume and distance travelled by each vehicle, life style and climate change. For these reasons emissions from road traffic must be estimated as accurately as possible.

CPCB has established the National Ambient Air Quality Monitoring (NAMP) Network, covering 209 cities/towns of the country in compliance with the mandate under the Air (Prevention and Control of Pollution) Act, 1981 to collect compile and disseminate information on air quality. The part of work associated with this, where Indian Institute of Technology Madras campus is taken as the reference site. The emissions from two wheelers (2stroke and 4- stroke engines), three wheelers and four wheelers are different. Based upon the consumption of fuels, distance travelled and emission factors (from the CPCB) pollutants from different types of vehicles are calculated. The procedure for classification and vintage of vehicles are strictly followed as per CPCB and Automotive Research Association of India **(**ARAI) norms.

II. METHODOLOGY

A. Study Area and Land use Pattern

Indian Institute of Technology Madras (IITM) campus, which is located right at the centre of the Chennai metropolitan city on the Sardar Patel Road, midway between the Raj Bhavan and Adyar bus terminus and flanked by Adyar, Taramani and Velachery. Other landmarks are: the Guindy Snake Park near the IIT main gate and the Central Leather Research Institute (CLRI) opposite to the IIT campus. The climate is generally hot and humid. In summer (May-July) the temperature reaches up to 42^0C while in winter (December- February) it is slightly less hot, 18^0C. The Monsoon season starts in September and lasts till November.

The entire land has been divided into four zones such as Academic zone, Residential zone, Hostel zone and wilderness zone. Each of these zones are comparable in size (approximately 60ha), though not in shape, configuration or topography. Bonn Avenue (BA), Madras Avenue (MA), Alumini Avenue (AA) and Hostel Road (HR) are the four main roads in the campus for transportation.

Catering to the needs of the student population and other on-campus residents are the banks, shopping centres, food joints, schools, hospital etc. which virtually make the campus self-contained and movement of vehicles to all these points are the main pollutant sources for vehicular emission. Two main parallel roads in the campus, Bonn avenue and Delhi avenue - connect the in/out gate of the campus and academic/hostel zones via Gajendra Circle (GC), main traffic intersection point in the campus. Main mode of transportation in IITM campus is, for hostel inmates, bicycle but residents in quarters and residents outside the campus are mostly using powered vehicles. Institute runs battery operated and diesel buses from gate to other locations at regular intervals from 6.15am to 10pm through BA, AA and HR. Private Vehicles coming from outside are directed through DA to academic and hostel zone. MA connects residential zone with academic zone. But people are mostly using Bonn Avenue which connects schools, kindergarten/play class, Banks, shopping complex etc. The transport from residential zone to academic zone, heavy vehicles for supplying stationeries, households, food and vegetables, milk and water and the vehicles coming to schools are the important sources of pollution.

B. Categorization of Vehicles

Vehicles are categorised according to ARAI, Pune. Data used for quantification pollutatns are - Engine capacity, model (engine strokes, 2S or 4S), fuel type, etc are taken from different vehicle manufacturers site, hourly vehicle volume data collected manually from main gate and Velacherry Gate during Week days and Weekends, parking volume study conducted in department and academic sections and total vehicles registered in the campus taken from the transportation section of the Institute. All the data collected are classified as in Table 1 and 2. The vehicle volume inside campus is high due to academic activities in weekdays. Traffic counts during Shaastra and Saarang festivals also taken to understand the increase of emission rates during these days. Emission factors are selected according to the vehicle category.

Table - 1
Category of Vehicles

Fuel / *Vehicle type*	*Gasoline (Petrol)*		*Diesel*		*CNG*		*LPG*	
2W	*2S*	*4S*	*2S*	*4S*	*2S*	*4S*	*2S*	*4S*
	<80CC	*<100CC*	-	-	-	-	-	-
	>80CC	*100-200CC*						
		>200CC						
3W	*<200CC*	*<200CC*		*up to 500CC*		*<200CC*	-	*<200CC*
				>500CC		*>200CC*		*>200CC*
4W (car and multiutility vehicles	*<1000CC*		*<1600CC*		*<1000CC*		*<1000CC*	
	1000-1400CC		*1600-2400CC*		*1000-1400CC*		*1000-1400CC*	
	>1400		*>2400CC*		*1400CC*		*1400CC*	
LCV			*<3000 CC*		*<3000 CC*		*<3000 CC*	
			>3000CC		*>3000CC*		*>3000*	
HCV			*>6000CC*		*>6000CC*			

Table – 2
Category of 2 Wheelers

Vehicle type	*Scooter*	*Motorcycle*	*Moped*
Stroke	*2S and 4S*	*Mainly 4S*	*2S*
Engine capacity	*90-150*	*100, 125, >125*	*50, 60*
Ignition	*Kick / Electronic*	*Kick/ Electronic*	*Kick/ Electronic*
Weight	*90-100*	*>100*	*60-70*
Engine power(bhp)	*6.5 to 9*	*7-8 and above*	*2-3*
Fuel efficiency (kms/litre)	*50-75*	*50-80 and more*	*70-80*
Load carrying capacity	*Higher*	*Highest*	*Low*

Source: Ex-showroom Mumbai Compiled by INGRES

C. *Estimation of pollutant load*

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kilograms of particulate emitted per mega gram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average).

The quantification is carried out using Emission Factors (EF) and formulae provided by Air Quality Monitoring Project-Indian Clean Air Programme (ICAP) - July 2007 for mobile sources/line sources and Air Quality Monitoring, Emission Inventory and Source Apportionment Studies for Indian Cities for point/ non mobile source / generators and LPG emissions. They generated the emission factors by testing 89 nos. of vehicles with approximately 450 tests. They considered vintage effect, fuel effect, and maintenance effect of the vehicles based on Indian driving conditions especially for Metrocities.

The analytical procedures are followed as per CPCB guide lines. Emission quantification calculations are carried out by assuming all the week days (260 days) are working days and the remaining (105 days) weekends. Usually Saastra and Saarang are conducted towards the end of week. 2 days each are deducted from total Weekdays and Weekends for Saastra and Saarang calculations (total 4 days from Week days and 4 days from Weekends).

The general equation for emission estimation is

$$E = A \times EF \times (1-ER/100) \quad \ldots\ldots (1)$$

Where, E = emissions, A = activity rate, EF = emission factor, and ER = overall emission reduction efficiency (%).

For vehicular emissions

$$\text{Emission load} = \text{length of the road} * \text{no of vehicles} * \Sigma (\text{Vintage of vehicles} * \text{emission factor}) \quad (2)$$

III. RESULTS AND DISCUSSION

A. *Quantification of Emissions*

Hourly emissions for all the four main roads in IITM are estimated separately. For quantification of emissions, the 2W vehicle count are categorized based on engine capacity by using the percentage obtained from the academic section parking volume study and for 3W and 4W the percentage is applied by noting the incoming vehicles while taking traffic volume count in IITM gate. 3W diesel and LPG vehicles are easily identified (diesel vehicles are only share autos and pick-up vans, those vehicles using LPG has green colour ring with "LPG" marking). Engine capacity of 4W vehicles available in Chennai is collected from different manufacturer's site. The average vehicular counts are calculated by averaging one month data for finding the emissions for Weekdays and Weekend and for Saarang and Shaastra the four days data were averaged to one day data (Table 3).

Table – 3
Average number of vehicle flow in IITM Roads

Vehicle Type	*2W*	*3W*	*4W-G*	*4W-D*
Weekdays	*2283*	*382*	*242*	*355*
Weekends	*615*	*27*	*19*	*65*
Shaastra	*2333*	*1460*	*1953*	*495*
Saarang	*194*	*1104*	*3004*	*1438*

The emissions are quantified by equation 2. Separate emission factors are used for CO, NO_X, SO_X, HC and PMs emissions based on engine capacity and models. It is found that the daily emissions from BA are higher than all other roads, BA road is one of the main road which links all schools, Banks, Post Office etc. The vehicle count in BA is also higher than other roads.

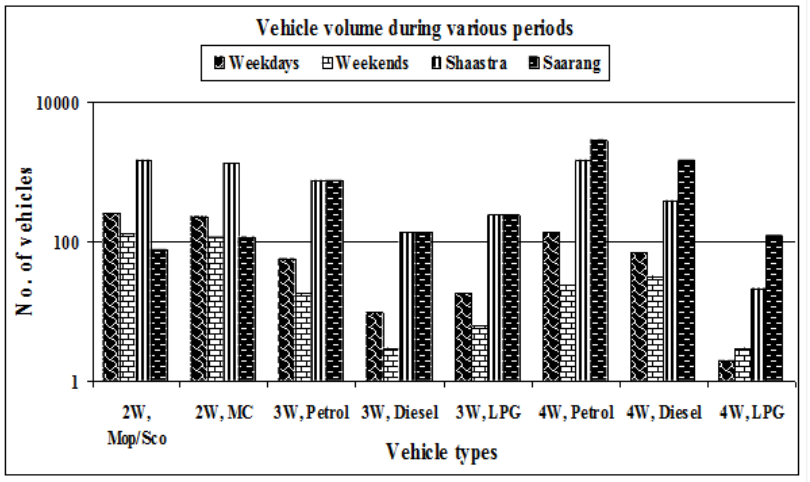

Fig. 1: Vehicle volume at various periods

Table - 4
Summary of pollutants emitted from in various periods (kg/day)

Pollutants	*CO*	*NO_x*	*HC*	*PM*	*SO_x*	*Total*
Weekdays	*12.147*	*1.728*	*5.501*	*0.253*	*0.010*	*19.639*
Weekends	*5.228*	*0.760*	*2.506*	*0.151*	*0.004*	*8.649*
Shaastra	*20.909*	*2.727*	*9.584*	*0.863*	*0.018*	*34.101*
Saarang	*19.604*	*5.869*	*5.888*	*1.182*	*0.020*	*32.563*

Emissions for CO, SO_X, NO_X, HC and PMs from each road are calculated separately and added together as Weekdays Weekends, Shaastra and Saarang. Total emissions during Weekend are very less compared to all other periods because of very less vehicular movement inside the campus. Other periods stands in the order of weekdays, Saarang and Shaastra. The total emissions are 2.3, 3.8 and 3.9 times more respectively than weekend emissions. Shaastra day emissions are coming little bit higher than Saarang day emissions because of the restrictions to 2W (separate 2W parking are arranged near main gate) to the campus.

The emissions calculated from Velacherry site shows that HC emissions from mopeds are very high in all the times than scooters and motorcycles even with very small count but the Particulate emissions are higher in scooters and motorcycles. Similar graphs are plotted for other site also.

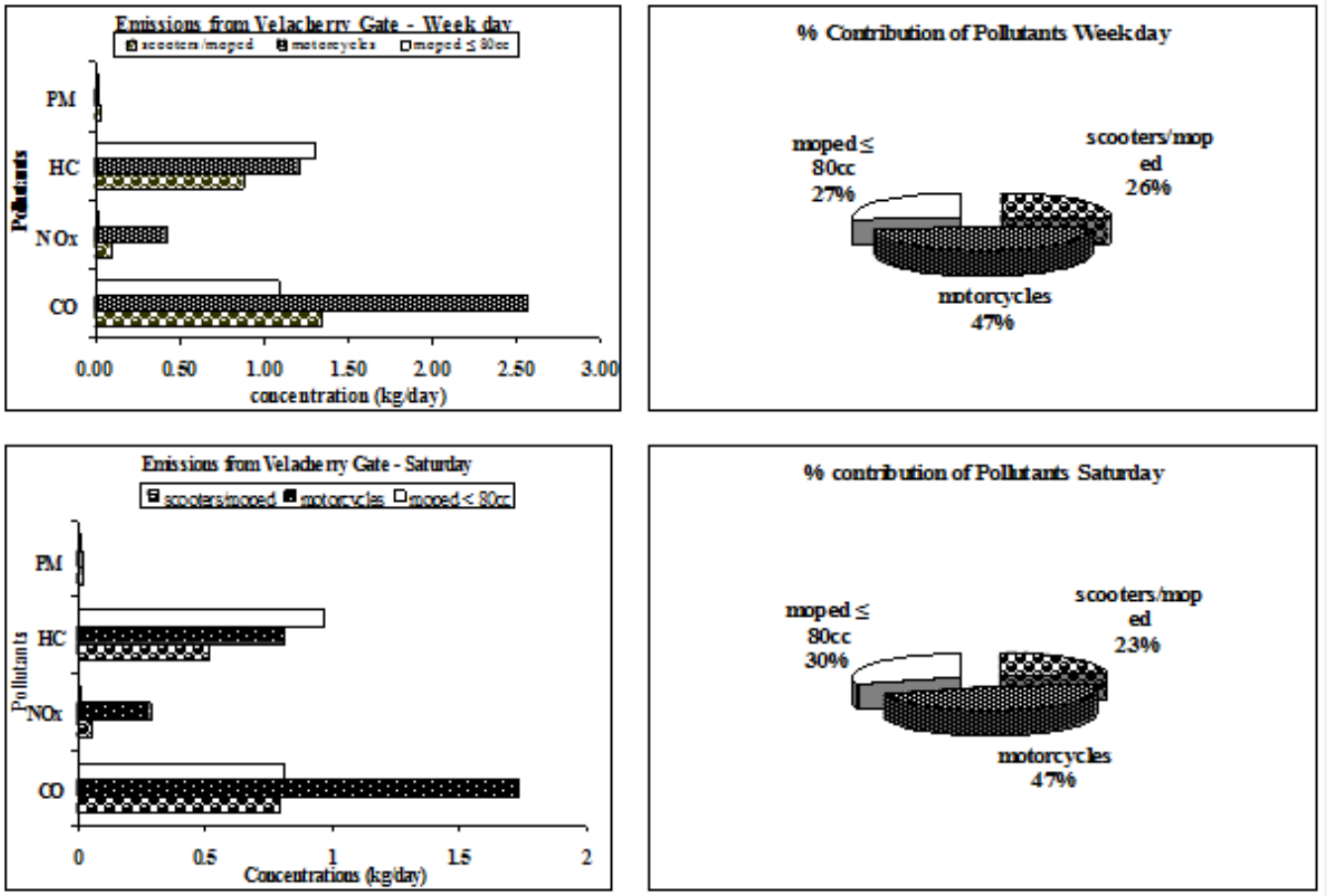

Fig. 2: Pollutant load in Velacherry Gate

IV. CONCLUSION

The study conducted in IITM Campus shows that more than 50 percent of people are using two wheelers and among that gents are using 4 stroke motor cycles and most of the ladies are using 2 stroke engines. During the peak times in working days vehicle count in campus roads are very high. Because of this reason the total emissions in kg per day are 2.3, 3.8 and 3.9 times more than weekend emissions for weekdays, Saarang and Shaastra respectively.

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