Findings fr Emission study conducted to assess Air Quality & Noise levels at Test & Control Roads

(*On comparable roads with/ without parking*)

In recent years concern about exhaust emissions from motor vehicles has been increasing. Exhaust emissions are a major contributor to air pollution due to the rapidly growing number of vehicles on roads in Indian cities such as Mumbai.

The effects of poor air quality on human health are far reaching, but principally affect the body's respiratory and cardiovascular systems. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status and genetics. The fuel combustion in vehicles is one of the major causes of presence of carbon monoxide, hydrogen sulfide etc. Other sources of air pollution include particulate matter (PM), ozone, nitrogen dioxide, and sulfur dioxide.

The traffic congestion and near grid lock situation has worsened due to rapid & substantial increase in parking on one/both sides of most roads, reducing the effective carriage way & forcing the vehicles to be driven in start- stop mode, half clutch mode as well as at very slow speeds which lead to partial combustion of the fuel, increasing the levels of the atmospheric pollutants per km driven and per minute occupation of road by vehicles.

This study aims at quantifying – at least to some definable extent – whether excessive, undisciplined & anywhere parking contributes to increase in pollution thru increase in traffic congestion and sub optimal conditions of driving.

We have quantified parking on a few representative road stretches (4-2). These parked vehicles are a major cause of congestion on these and connecting roads, which in turn affects air quality.

In order to quantify the emissions on roads where traffic is affected by parking, we identified 1 road as control (where there is almost no parking but high traffic volumes) and 4 road stretches as test sites. Both the control & test sites were similar in terms of traffic volume, no. of lanes etc but differed in terms of parking on the roads (which was mostly absent in control and substantially present on Test roads). The chosen roads were as follows:

	Names of roads selected	**Type**	**Space occupied by parking in %**
1	Dr Annie Besant Rd (Worli)	control	No parking
2	Linking Rd (Bandra)	Test	45
3	E Moses Rd (Worli)		60
4	Mohammed Ali Rd (under JJ F/o)		75
5	N.C.Kelkar Rd (Dadar)		**

*** Within 700 m of this road, there are 4 entry exit lanes with huge both sides parking, which in effect is parking for N.C kelkar road, which is a major shopping area strategically located almost outside Dadar station. Direct parking is also observed to some extent.*

Observations were recorded at an interval of 15 minutes since morning to late evening for full normal dry working days in mid June 2014. On each road observations have been identified for peak congestion period and off peak (lean) period and it was invariably found that emissions are significantly higher during peak periods when the occupation of road by flow of vehicles is higher (i.e. there is very high incidence of stop start driving due to traffic congestion.) The observations were recorded for the following along with the vehicle flow counts:

1. Level of Particulate matter (PM)
2. Levels of Carbon monoxide-CO
3. Decibel levels
4. The number of vehicles passing counted thru a manual counter.

Data Compilation and Analysis

This work was entrusted to ***Environment Policy & Research India*** (**EPRI**), an organization which specializes in this type of work. We jointly worked out the selection of sample, method of data collection and its interpretation ensuring that the results are reliable and significant.

1. All the samples were collected from 8.00 am to 8.00 pm (12 hours a day)
2. All the air quality parameters were collected at an interval of 15 minutes. Thus four readings per hour were obtained.
3. Vehicle counting was carried out on continuous basis for 12 hours.
4. Collected data was brought to the laboratory and then analyzed using statistical software.
5. Statistical analysis of the data was carried out with the help of Microsoft Office Excel.

Peak period vs non peak period

Following table gives the vehicle count on all the above roads for peak hr peak direction and the lowest no. (Presumably at off peak hr) - Table-1

Road stretch #	**Type**	**Peak hr (PCUs)**	**Off Peak (PCUs)**
Annie Besant Road- worli	Control (no parking)	3754	3396
N.C. Kelkar Road- Dadar**	Test (high parking)	*1586*	***2035***
Linking Road – Bandra w	Test (high parking)	2839	1907
E. Moses Road-worli to M'laxmi	Test (high parking)	1183	982
Mohd Ali Road- (under JJ flyover)	Test (high parking)	1158	1036

*** On this road, traffic congestion is so high during peak hours that due to drastic reduction in traffic speeds, the actual thruput declines as compared to off peak period. On this road, congestion is observed even during some non peak hours*.

Above table shows that the vehicle thruput is higher during the peak hr (with the exception of Dadar where hour wise distribution of vehicles flow is flat. Control road also has a high volume of traffic but it is much smoother than the test roads. Parking on roads is an important (but not the only) element which makes a difference to traffic flows and the emissions.

Also due to choked traffic, the no. of vehicles actually goes down during peak hr. We have observed similar phenomena at BKC, Haji Ali and a few other locations as observed at N.C.Kelkar Road. We expect this will increase at more locations where the traffic completely overwhelms the carrying capacity of the road – needless to say , this is intensified further due to extensive and chaotic parking on both sides of the road ! Typically, on roads where there is some "idle" space on the carriageway during off peak hours gets filled up during the peak hr.

We also notice over the period of time, that the gap between peak and non peak hr is going down. In case of Dadar, there is already full capacity utilization during off peak hours and hence the traffic thruput goes down /slows down during the peak hr as the vehicles are totally in stop start mode. If there is no parking, the flows would certainly be higher and smoother. As we reach the physical capacity of road lanes to carry traffic at a given speed, then the thruput goes down and emissions go up.

Emissions due to Traffic levels

Motor vehicles emit large quantities of carbon dioxide (CO_2), carbon monoxide (CO), Hydro carbons (HC), Nitrogen oxides (NOx), Particulate Matter (PM), and substances known as mobile source air toxics (MSATs) such as benzene, formaldehyde, acetaldehyde. These substances produce extreme environment hazards.

PM is a widespread air pollutant consisting of a mixture of solid and liquid particles suspended in the air. Commonly used indicators describing PM that are relevant to health refer to the mass concentration of particles with a diameter of less than 10 µm (PM_{10}) and of particles with a diameter of less than 2.5 µm ($PM_{2.5}$). $PM_{2.5}$, often called fine PM, also comprises ultrafine particles having a diameter of less than 0.1 µm

Difference in Particulate matter at test and control road stretches – Table -2

Site	Type	Peak hour			Off peak hour		
PM (µg /m^3)		**1**	**2.5**		**1**	**2.5**	**10**
Annie Besant Road	**C**	**376**	**482**	**622**	**228**	**227**	**417**
N.C.Kelkar Road	(T)	632	756	929	210	303	377
E.Moses Rd-Worli	(T)	1470	1010	2160	677	829	1360
Linking Rd Bandra	(T)	819	944	1220	196	274	369
Mohammad Ali Rd	(T)	892	974	1961	522	589	658

(*The national average standard for PM $_{2.5}$ is 60 µg /m^3 & for PM $_{10}$ it is 100 µg /m^3)*

Observations with regard to particulate matter at all the test roads clearly show that they are higher as compared to control site and much higher than the national average standard for the same, (which is *60 µg /m^3 for PM 2.5 & for PM $_{10}$ it is 100 µg /m^3).* Also they are much higher in peak hr as compared to off peak hr in a very decisive manner (2 to 3 times!).

The table also shows that the total of all particulate matter for each of the test roads is over 100% higher than the control roads during peak hour (except in case of Mohammad Ali Road, which shows higher PM total during off peak hour)

Average levels of Carbon Monoxide(CO) at Test & control sites – Table 3

Site	Type	Average-PPM	Comparison of Test vs control
		CO	%
Annie Besant Rd, Worli	**Control**	**2.9**	
Mohammed Ali Road	Test	22.6	**779**
N.C.Kelkar Road, Dadar	Test	16.8	**579**
Linking Road, Bandra	Test	14.5	**500**
E.Moses Road, Worli	Test	12.0	**414**

The CPCB-Central Pollution Control Board - national average standard for CO is 3.5 PPM

The CO levels at N.C.Kelkar Road and Linking Road are almost the same. Mohammed Ali road shows the highest CO level. Also on all the test roads, the values are more than 3-4 times higher than the national average standard for CO.

Effects of very slow movement of vehicles due to congestion on emission (excerpts and references)

"Traffic congestion reduces average traffic speed. At low speeds, scientific studies reveal, vehicles burn fuel inefficiently and lead to more pollution level. ***For example, a study in the United States found that for the same trip, cars consumed more fuel and polluted more if the traffic was congested, than when traffic flowed freely. At average trip speeds between 20 to 40 km/hr, the cars pollutant emission was twice as much as when the average speed was 55 to 75 km/hr. At average trip speeds between 5 to 20 km/hr, the cars pollutant emissions were 4 to 8 times as much as when the average speed was 55 to 70 km/hr. Fuel efficiencies similarly were much worse with traffic congestion.****(Matthew Barth and Kanok Boriboonsomsin (November 2009)*

The **average trip speed** on many Indian city roads, especially in metros, is **less than 20 km/hr; a 10 km trip can take 30 minutes or more**. **At such speeds, vehicles in India emit air pollutants 4 to 8 times more than they would with less traffic congestions,** Indian vehicles also consume a lot more fuel per trip (leading to *even more emissions*!) than they would *if the traffic congestion was less*. Emissions of particles and heavy metals increase over time because the growth of the fleet and mileage outpaces the efforts to curb emissions (R. Kumari, A.K. Attr 2008). "

Noise Related Health Issues -

Besides the adverse effects of the air pollution, elevated levels of noise have become an inseparable part of our roads. Noise pollution is a significant environmental problem in cities like Mumbai, and is a serious health hazard in terms of:

1. hearing impairment,
2. hypertension,
3. ischemic heart disease,
4. annoyance,
5. sleep disturbance
6. Changes in the immune system

Noise Level in decibels (dB) – Table-4

Site	Type	Noise level-dB		PCUs	
		peak	off peak	peak	off peak
Annie Besant Rd, Worli	**Control**	**80-85**	**75-80**	**3754**	**3396**
N.C.Kelkar Road, Dadar	Test	90-95	70-75	1586	2035
Linking Road, Bandra	Test	90-95	65-70	2839	1907
E.Moses Road, Worli	Test	95-100	65-70	1183	982
Mohammed Ali Road	Test	95-100	70-75	1158	1036

The table shows high decibel levels on Mohammad Ali Road as well as N.C. Kelkar Rd - at peak hour- as compared to the control road implying the impact of traffic congestion. On the other hand, at off peak hours, there isn't any distinct difference between the noise levels at the control or test sites, as the flow of traffic is relatively smooth and use of horn is less - An observation that makes sense. Since honking, though futile (on congested jam packed road!) greatly contributes to noise pollution.

Conclusion and way forward

Finally, comparison of the findings at the test and control road sites as well as peak and off peak hrs shows that traffic congestion, slow moving vehicles and unmanaged pedestrian movement due in a substantial manner on account of poor quality of footpaths ***and last but not the least chaotic, unregulated& free parking*** contribute in a decisive manner to a substantial increase in PM & CO emissions and an increase in decibel levels.

Our choice of roads with and without parking also clearly implies that undisciplined parking which occupies at least one lane (out of 2- 3 lanes) is a major contributor to the increased congestion, leading to slow as well as stop-start driving leading, in turn, to *materially increased emissions*. Together with other adverse impacts mentioned elsewhere in the report, these findings must be taken into consideration in transport planning to contribute to keeping the traffic movement in a free flowing manner thereby regulating emissions.

Regulation of parking can be a good and effective starting point towards this goal. It is one of the quick wins, which is also revenue positive. If there is a lack of enough reasons for taking step which is somewhat unpleasant to a few thousand motorists in a city of 13 million, a great increase in pollution can certainly be one more powerful reason.