Air Pollution from Transportation Sources in Bangalore

Call to Action Report

Preliminary Draft

Prepared By
Mahesh Kashyap

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(placeholder for CISTUP)

Introduction

Bangalore is one of the fastest growing cities in Asia with a population of over 9 million and growing rapidly in all directions (360 degree). As the population increased, so has the number of vehicles on the road. According to the transport department, Bangalore has become more congested since 2008. The number of vehicles[1] on the roads has increased from 29.27 lakhs (2.29 million) to 34.91 lakhs (3.49 million) in just two years from 2008-2010 (this figure does not include vehicles that are registered outside the city and state).

There are about 40 lakh vehicles[2] in Bangalore. The city contributes nearly half of the total vehicle population in the state. Number of vehicles in Bangalore is growing by the day. As per official figures[1], 70% are two wheelers, 15% are cars, 4% account for autos and 8% buses, trucks, tempos, vans, etc. Also there are about 10,000 illegal autos per the government sources. Following table provides an estimate of vehicles based on the percentage.

Table 1

Vehicle Category	Population %	Number of vehicles
Two Wheelers	70	28,00,000
Cars	15	6,00,000
Autos	4	1,60,000
Bus, trucks, vans, tempos	8	3,20,000

Note: Values do not add up to 40 lakhs

Air pollution arises from different sources such as industrial activities, open burning, fuel combustion, evoporation, etc. One of the major source of air pollution is from transportation sources due to the exhaust gas from the tail pipe, mainly due to incomplete combustion of fuels. Key air pollutants, also referred as Common Air Pollutants (CAP) are emitted due to the vehicular traffic. Health effects of air pollution are already well known.For example, carbon monoxide (CO) slows the delivery of oxygen to the body's organs and tissues. Exposure to CO aggravates heart disease and can cause headaches and visual impairment. One can see number of traffic police pesonnel wearing mask while on duty. Also many two wheeler riders are wearing handkerchief covering their mouth and nose to prevent or reduce inhalation of exhaust gases.

CAP include Total Particulate Matter (TPM), Particulate Matter less than or equal to 10 microns (PM10), Particulate Matter less than or equal to 2.5 microns (PM2.5), Sulphur Oxides (SOx), Nitrogen Oxides (NOx), Volatile Organic Compounds (VOCs), and Carbon Monoxide (CO). Emissions of CAP contribute to smog, poor air quality and acid rain.

Note: Current discussion is only rstricted to CAP. Toxic air emissions from transportation sources are not included at this point of time as the attention need to be given immediately for the CAPs.

Irrespective of the perceived quality of the air, we should strive hard to make it better. The air we breathe is free, lets not abuse it.

Control Measures

There are number of action items that can be incorporated to reduce pollution by CAPs from transportation sources in Bangalore. They are discussed briefly below:

a. Location of Exhaust

Figure 1

Currently the exhaust system in the vehicles in Bangalore (almost everywhere in India) is located at the bottom of the vehicle and is at the breathing level (see above photo). The location of exhaust system from where exhaust gases containing potential air pollutants are emitted, affects pedestrians and riders of other passenger vehicles specifically the two wheelers and autorickshaws that are prevalent on Bangalore roads.

Why vertical exhaust?
The biggest advantage with vertical exhaust is the vertical dispersion of the air emission with no exhaust at the breathing level. As mentioned above, this would be a great relief and respite for the riders of two wheelers and autorickshaws.

One problem that could arise would be with trees branches on the road that could potentially damage the exhaust pipe. Concerned authorities must ensure trimming of the branches.

Action: There is an urgent need for installing vertical exhaust (see photos) for diesel based heavy duty vehicles such as buses and trucks. The Government needs to negotiate with the diesel based heavy duty vehicle manufacturers to install vertical exhaust on all the new vehicles.
Note: Vertical exhaust for the bus in the photo is located on the rear top on the left of the bus.

Figure 2

b. Grandfathered Vehicles

There are number of four wheel diesel vehicles that are old and are "grandfathered". The engine may be losing its efficiency due to number of factors including tampering. One of the important results is incomplete combustion of diesel fuels in the engine causing dark coloured exhaust from the tail pipe at the breathing level.

Action: Steps must be taken to reduce or eliminate these types of grandfathered vehicles

c. Testing of emissions from vehicles including Heavy Duty vehicles

Vehicles such as cars and motorcycles are tested for their emissions. It is not clear at this time if other vehicle categories such as diesel trucks / buses and vans are tested. One can visually see the dark coloured exhaust coming out of the tail pipe from these vehicles (including number of government vehicles).

Action: There is an urgent need for a robust inspection and testing programme for the vehicles including heavy duty vehicles. The mandate should be under the guidance of KSPCB rather than Transport or Police department. KSPCB enforcement staff trained in this process must be given the responsibility for inspection and testing. Also the inspection should ensure there is no tampering o the engine. In addition, the authorities must ensure proper maintenance and calibration of testing equipment used.

d. CNG as fuel[4]

In a test representing congested urban traffic, CNG outperformed petrol powered vehicles on emissions of carbon monoxide (CO). Indeed, emissions of CO from CNG powered vehicles are of the same order as those emitted by diesel vehicles. Emissions of NOx and particulates from CNG powered vehicles are significantly lower than those from diesel vehicles. Moreover, emissions of NOx from CNG vehicles are half those from equivalent petrol engine vehicles.

A recent study[4] using a small delivery van fitted with a three way catalyst and capable of switching between CNG and petrol, showed that on a modified European Union emission test cycle, emissions of Carbon Monoxide non-methane hydrocarbons (NMHC) and Nitrogen Oxides were 76%, 88% and 83% respectively lower with CNG than with petrol. Using data from other studies CNG also compares favourably with emissions from equivalent sized diesel engine vehicles.

There are number of autorickshaws in the city that run on duel fuel, petorl and gas. These vehicles have four stroke engines threby reducing air pollutant emissions from the exhaust.

One of the biggest potential drawback of CNG as fuel is its contineous supply. If the heavy duty vehicles are converted to CNG, the government must ensure uninterrupted supply of CNG.

Action: Public transit buses need to be retrofitted with CNG as fuel. It appears that New Delhi has its public transit buses fitted with CNG.

Diesel vs CNG

The following paragraph is from Centre for Science and Environment website[5] that is commenting on the study conducted by Ministry of Environment and Foerst, Government fo India, comparing diesel and CNG:

"First the key partners of the Central Pollution Control Board -IOC and NEERI involved with yet to be released source apportionment study made claims publicly that LPG is the most polluting fuel in our cities. Now in quick succession a second study follows from CPCB that ranks CNG as the "worst" fuel and Euro II-III diesel as the "best". No other government in the world has every branded CNG as worse than Euro II-III diesel."

It appears that there is lack of consensus between the departments and the stakeholders. There need to be a detailed discussion and consensus in this regard.

e. Sulphur in Fuel

Sulphur in fuel when combusted turns into Sulphur Oxide which is harmful to the health and environment. Rrestrictions on the Sulphur content in fuel is in place worldwide and have become tougher. Pollution due to Sulphur Oxides is particularly noticeable through acid rain and smog. At the same time, Sulphur may poison the catalyst in vehicles that could lead to higher emissions of Nitrogen Oxides. High concentrations of sulphur in fuel may lower the efficiency of pollution control systems in a vehicle.

In India, the maximum level of Sulphur content in diesel fuel is 350 ppm. According to the UNEP[6], the Indian government has issued a notification[8] to introduce Euro IV standards and 50 ppm Sulphur fuel in eleven cities by April 1, 2010.

In comparison, according to Department of Transport, Government of Canada, the following are the Sulphur contents in fuels:

- Gasoline manufacturers must restrict the content of sulphur in gasoline to an average of 30 parts per million (ppm)
- Sulphur content in diesel fuel must not exceed 15 ppm

Though the regulations requires 30ppm for Petrol, reporting by the industry reveals that the target is achieved and even still reduced to 25ppm. For emission inventory purposes[9], the value of 25ppm is used. Similarly Sulphur content in diesel fuel is below 15 ppm. For emission inventory purposes, the value of 10ppm is used.

Following table shows Canadian transportation air emissions[3] and the percent contribution to the total air emissions. Note that the SOx emissions are relatively low due to the low Sulphur in petrol and diesel in Canada.

Table 2

Pollutants------->	**TPM**	**PM10**	**PM2.5**	**SOx**	**NOx**	**VOC**	**CO**
Total Transportation Emissions (tonnes)	12,274,274	3,504,427	630,378	69,839	69,314	62,262	93,285
% of Transportation Emissions of the Total Emissions*	64.46%	56.19%	48.76%	5.38%	50.08%	2.01%	60.88%

Action: Efforts should be made to further reduce Sulphur content in petrol and diesel fuels for the vehicles in Bangalore.

f. Four-stroke engine vehicles including motorcycles

The advantages of four-stroke engines are very well known. Currently there are too many two-stroke engine vehicles on the road. The disadvantages of two-stroke engines are:

- Two-stroke engines produce more pollution from the combustion of the oil in the gas. The oil makes all two-stroke engines smoky to some extent, and a badly worn two-stroke engine can emit more oily smoke.
- Each time a new mix of air/fuel is loaded into the combustion chamber, part of it leaks out through the exhaust port.

In two-stroke engines, the intake and exhaust cycles are combined into a single piston stroke, and a mixture of air and fuel blows the exhaust products out of the engine. Four-stroke engines use four distinct piston strokes to control the fuel and exhaust cycles. As the piston shoves out the exhaust, less unburned fuel is emitted into the water and air.

Currently, there are number of autorickshaws in the city that have duel fuel four stroke engines threby reducing air pollutant emissions from the exhaust.

Action: Efforts must be made to increase the number of four stroke engine vehicles and reduce two stroke engine vehicles.

g. Public Transport such as Metro / Mono Rail

Introduction of metro Rail is a great welcome relief for Bangalore. Still there is a need to reduce and control air emissions from transportation sources even after the Metro Rail is fully operational. As planned, metro rail runs from North-South and East-West corridors of the city. Other areas still depend on bus and other modes of transportation.

As discussed in the introduction section, currently there are 40 lakh vehicles on road in the city. When the Metro Rail is fully operational in future, tens of thousands of vehicles may be off the road when the public start using the rail system. Thousands of two wheelers, autos and cars on the road would be reduced. If there is a ridership report from BMRCL, it should give more accurate numbers.

As discussed earlier, currently there are about 28,00,000 two wheelers and 6,00,000 cars on the city roads[2]. By the year 2015, assuming the Metro rail is fully operational in the city, the number of two wheelers and cars may be at the current levels of 2011 or a slight increase of 2 to 4 percent (this is a very conservative estimate) as people will continue to buy newer vehicles. People living and working in areas that are not close to the metro / mono rail station and feeder buses still depend on other modes of transportation. The amount of air pollutants emitted to the air from these vehicles may remain the same (at the 2011 levels) by 2015. At the same time, the number of heavy duty vehicles such as buses and trucks may increase as the metro rail needs feeder buses. The number of these vehicles may cross 4,00,000 by 2015 increase their share of air emissions. Therefore, action must be taken to reduce air emission from these vehicles through the use of technology, alternate fuel, vertical exhaust, etc.

Note: It would be difficult to predict/forecast the number of vehicles on the road in Bangalore by 2020 or 2025. Forecast of vehicle population mainly depends on the population forecast. With the introduction of Metro rail and other public transportation measures, it would be difficult to predict the number of vehicles on the road in future. Increase in the public transportation services would not stop vehicles being added to the roads in the city, though it may not be at the current level. Therefore it may not be possible at this time to forecast air emissions from transportation sources.

Action: Expand metro rail system and connect with the suburban rail system. Also introduce more buses that are run by CNG rather than diesel.

h. Transportation emissions are local

Currently air quality sensors and monitors may not be able to take the transportation emissions into account since the exhaust emissions are at the ground level or breathing level (see figure 1) and may not disperse properly over a period of time. Therefore air quality monitoring data may not reflect transportation air emissions in the data since the monitors may not catch air emissions from vehicles from different areas of the city.

Action: Conduct spot checks using sensors and analyzers to test emissions from vehicles. Care must be taken in analyzing monitoring data for transportation emissions.

i. Comprehensive air emission inventory for transportation sources

A comprehensive air emission inventory should be developed for transportation sources to meet the following purposes[3]:

•Inform public about pollutants that affect their health and the environment
•Identify priorities for action;
•Develop and track progress on air quality management strategies, policies and regulations;
•Fulfill any domestic and international reporting obligations (India and the state of Karnataka are not signatories for any domestic or international protocols).
•Identifying pollution prevention priorities;
•Supporting the assessment and risk management of chemicals.

Air quality monitoring data may not be feasible in developing policies and rules. Air pollution from transporation sources are local. The monitors that are located in the city may not be able to catch pollution from on-road vehicles. Reliance on the monitoring data in developing policies and rules is not be advisable. Only a comperhensive air emission inventory for transporattion sources will be a best policy development tool. Note: Current discussion is only rstricted to CAP. Toxic air emissions are not included at this point of time as the attention need to be given immediately for the CAPs.

Action: A comprehensive air emission inventory must be developed for the Common Air Pollutants (CAP) followed by air toxics for transportation sources. This exercise should be expanded to include the entire state of Karnataka.

j. Fugitive Dust from paved and unpave roads

Fugitive Dust is defined as any solid particulate matter that does not come from a stack or a vent or a tail pipe.

There are number of unpaved roads in the city that contribute fugitive dust emission when vehicles are driven over them. Fugitive Dust is the major contributor to the total particulate matter emissions and must be controlled. Paved roads also produce fine dust as their surfaces wear out. In addition, there are materials such as sand, mud and debris laying on the paved roads during and after rconstruction related activities. When the vehicles are driven over them, it causes fugitive dust emissions.

Action: Unpaved roads must be paved with asphalt as soon as possible. Another method of controlling fugitive dust is to spray water on the road. But this method may not be feasible due to availability of the water needed. Sand, mud and debirs lying on the paved

roads due to construction related activities must be quickly removed to reduce fugitive dust when the vehicles are driven over them.

k. Other General Measures

Humps and ditches / troughs on the roads
(placeholder for pictures)

There are number of agencies in the city that are involved in providing various logistics and infrastructural services. The activities include digging across the road for laying telephone cables, water pipes, etc. When the work is completed, many of dug up roads are not leveled up to the road level. This creates a hump, an "artificial speed breaker" or a ditch / trough. Some of the vehicles, light or heavy duty, has to come to a complete stop and go over the hump / trough. The vehicles have to accelerate after crossing the hurdle. This causes unwanted / unnecessary extra additional load of pollution to the air from the exhaust. If the road is leveled after digging and work completion, there will be smooth flow of the vehicles without stoppage resulting in elimination of the extra unwanted exhaust emissions.

Action: The filling of the area that is dug on the road need to be done quickly as soon as the work such as laying telephone cables, water pipes, etc is completed.

Spot check
As mentioned in item (h), transportation air emissions are local. Therefore spot checks and testing of exhaust emissions from vehicles must be conducted based on visual observation of the exhaust gases. Concerned staff must be properly trained to do this exercise. The system would screen out individual vehicles with excessive emissions. Those vehicles that fail the spot check would then be directed for further actions such as additional follow-up inspection and testing.

Action: Develop on-road sensors for this purpose. Number of these sensors must be fanned out across the city with a staff of 2-3 individuals to test and monitor the exhaust gases from vehicles.

Preventing adulteration of fuels (mainly diesel with kerosene)
The adulteration of fuel is prevalent in across the country. The recent killing of a government official in the state of Maharashtra has shown how the adulteration of diesel fuel with kerosene is rampant. This not only hampers engine performance, but also pollutes more from the heavy duty vehicles due to the presence of increased Volatile Organic contents in Kerosene.

Action: The authorities must ensure that there is no adulteration of diesel and petrol.

Buses and vans in the residential areas
There are number of and buses vans run by diesel fuel go through residential areas to pick up school / college going passengers (students and staff) and office goes (mainly BPO

staff). Some of the areas have smaller roads with buildings that are densly populated. Most of the buese and vans that go through these areas are old that have engines with incompelte combustion of the diesel fuel. When buses and vans go in every street to pick up passengers, this would increase pollution in the residentail areas. This is an extra load of pollution to the air.

Action: Riders ould be asked to assemble in a central location rather than the bus/van going to pick up each passenger. This would reduce air emissions from diesel fuel in the residential areas as the bus covers only a small part of the residential area.

Public Participation

The public must be encouraged and urged to identify and report on-road excessive polluters or other high emission vehicles. This is only possible by visual observation of the exhaust emissions. If the system is in place currently, it needs to be evaluated for its effectiveness. The information collected may include the type of vehicle (van, auto, etc) and license plate number of the vehicle. One of the issues in this process is that it may be difficult for the public to note the license plate number while driving and the license plate number numbers are long. Also some of them may be out of the state vehicles.

Action: A massive public relation and awareness campaign must be undertaken for the public to participate in this process. The awareness campaign must include health effects of air pollution from transportation sources. If the system is not in place currently, it must be set up immediately. A hotline must be set up to receive information from the public. The callers must be kept anonymous (unlike RTI applicants). Concerned authorities must follow up diligently.

Speed breakers on one way going up slope.

There are number of one way streets in the city that are upslope and have speed breakers. This causes acceleration of vehicles during and after going over the speed breaker on the upslope road. This causes more exhaust from heavy duty vehicles at the breathing level. Concerned agencies must look into the viability of reducing the number of speed breakers on one way going up slope

Flexible Hours[11]

Introduce flexible or compressed working hours for employees, schools and colleges in the busy central area of the city. As a start, the Government. can lead the way by introducing flexible working hours to employees in and around Vidhana Soudha and multi-storey buildings, say within 1 km radius of the Vidhana Soudha.

Traffic management measures

1. Promoting the use of public transportation such as buses and metro / mono rail
2. Expanding paid motorcycle parking areas near the Metro rail and bus stations
3. Encourage car pooling

Reducing Idling Time

Like driving, idling of vehicles releases pollutants into the air. Idling is unnecessary thereby saving fuel and reducing extra load of pollutants to the environment. Reducing idling is an easy way to reduce vehicle emissions. An hour of automobile idling burns approximately 0.8 litres of petrol[10].

PM10 emissions from petrol vehicles are negligible, especially when the elimination of lead in petrol. Heavy-duty diesel vehicles emit VOC, CO, NOx, and PM_{10} during idling.

Action: A massive public relation and awareness campaign must be undertaken to educate the public regarding idling of vehicles. The awareness campaign must include health effects of air pollution due to idling, engine efficiency and fuel usage. Vehicles must be tested during idling process in order to get a benchmark idling time (in minutes) that can be used to develop policies for air pollution and traffic (at the stop lights and road intersections).

Summary

Air pollution from transportation sources are local and prevalent in Bangalore. There are number of action items that can be implemented to reduce air pollution from vehicles. In the end what matters is the willingness to implement the actions. The actions are summarised below:

- Development of realistic policies and rules through a comprehensive emission inventory of air emissions from transportation sources
- Installation of vertical exhaust for heavy duty vehicles such as buses and trucks
- Elimination of grandfathered vehicles
- Using ultra low Sulphur fuels
- Introduction of more public transportation system such as metro / mono rail and buses
- Improving the existing mass transit such as using the suburban railway systems as mass transit for suburban population.
- Robust inspection and testing programme for vehicles
- Public participation
- Reducing idling
- Increase in the number of four-stroke engines
- Reduction in the number of diesel vehicles
- Increase in the number of CNG and Electric powered vehicles
- Better maintenance of existing city roads

Immediate Actions

1. Set up a face to face meeting with the important stakeholders to discuss air pollution issues from transportation sources in Bangalore. The stakeholders must include important players such as vehicle manufacturers.

2. Form a core group of dedicated and experienced professionals to initiate action in reducing air pollution from transportation sources for Bangalore.
3. Provide the core group with enough resources (monetory and manpower) and authority, as necessary, to carry out the actions necessary to combat air pollution from transportation sources.

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