



Impact of Enforcement of Vehicular Emission Norms and Automobile Technologies on the Vehicular Pollution Loads in Delhi

Dr. Nibedita Khuntia*, Lakshay Sharma**, Junaid Arham**

**Assistant Professor, Department of Biology,*

*** B. Tech, Department of Computer Science –
Maharaja Agrasen College, University of Delhi*

ABSTRACT

Motor vehicles are emerging as the largest source of urban air pollution due to the rapid increase in the numbers and limited use of emission control technologies. Although the vehicular population in Indian metropolitan cities is much less compared to that in developed countries, unmaintained vehicles, outdated engine technologies and designs, inefficient road networks, erratic driving patterns and congestion due to mixed & slow-moving traffic all add to the air pollution problem. If timely efforts are not being made to eradicate the problems that have emerged due to vehicular emissions, the cities will continue to deteriorate and will gradually become miserable. This report presents a review of the vehicular emissions in Delhi and the various measures adopted by Government and automobile manufacturers for its reduction.

Key Words: Emission norms, Delhi, vehicles, transport modes, air pollution, particulate matter, green fuels

INTRODUCTION

In developing countries, growth and development in different spheres have triggered a considerable rise in the number and use of motor vehicles. More measures can and should be undertaken to encourage a balance use of different transport modes-be it 2W, 3W, 4W, freight transport, land transports, railways and air transports. In 2013, transportation contributed more than half of the carbon monoxide and nitrogen oxides, and almost a quarter of the hydrocarbons emitted into our air.

Since 1990, the Government has been trying to decrease the vehicular emissions by introducing various emission norms, but the condition remains stranded as there is continuous increase in the number of vehicles which in turn make all the efforts to curb the pollution to no purpose.

VEHICULAR POLLUTION

Low usage of green fuel driven vehicles: The biggest source of vehicular pollution is the usage of vehicles that run on conventional fossil fuels like petrol and diesel. The burning of these fossil fuels releases smoke and various greenhouse gases. With rapid increase in the number of vehicles and no substitute for petrol and diesel, vehicles are still dependent on these fossil fuels and thus, emerge as one of the biggest threats to the environment

Particulate matter: The exhaust by a car is marked by a black, thick coating of soot. Sometimes lots of it accumulates and when the car moves, the soot spreads on the ground and can easily be carried away by air. This particulate matter is harmful to people's health as well as to the environment.

Improper Vehicle Maintenance: Vehicle maintenance has a huge role to play in emissions. A vehicle that lacks maintenance will have higher emissions and will release more unburnt fuel into the environment in comparison to a vehicle that is well maintained. A well maintained and lubricated vehicle is not only efficient in performance but also ensures it has lesser emissions.

EMISSIONS

Pollutants that are emitted by vehicles are carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x), particulate matter (PM), lead (Pb) and Sulphur dioxide (SO₂). SPM (Suspended Particulate Matter) and RPM (Respirable Particulate Matter) are the most critical pollutants in the capital city with respect to the air quality measurements. Both have regularly crossed the prescribed limits at almost all the monitoring locations which in turn indicates a situation of huge threat on mankind. Their concentrations are high even in residential areas. The heavy-duty diesel-driven vehicles are still a significant source. Stricter enforcement of norms and regulations need to be taken into consideration to ensure that these pollutants don't cross the prescribed limit and thus ensuring a good quality air. High-traffic zones, inefficient traffic management and sudden increase in the number of vehicles are reasons of increasing the levels of CO and NO_x.

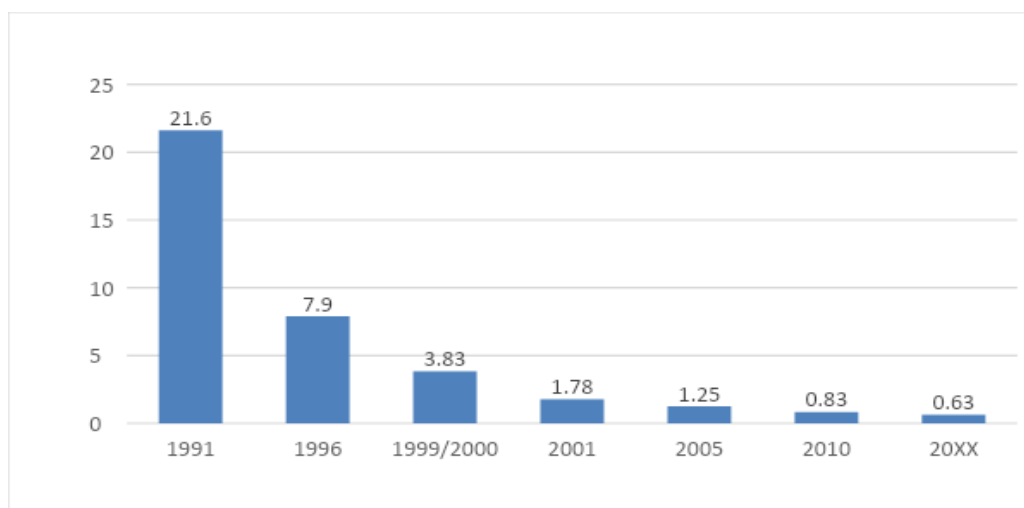


Figure 1. Regulated pollutants in (g/km) from 1991 (year of enforcement of first emission norms) to 20XX (year of enforcement of Bharat Stage VI norms in future) for diesel cars.

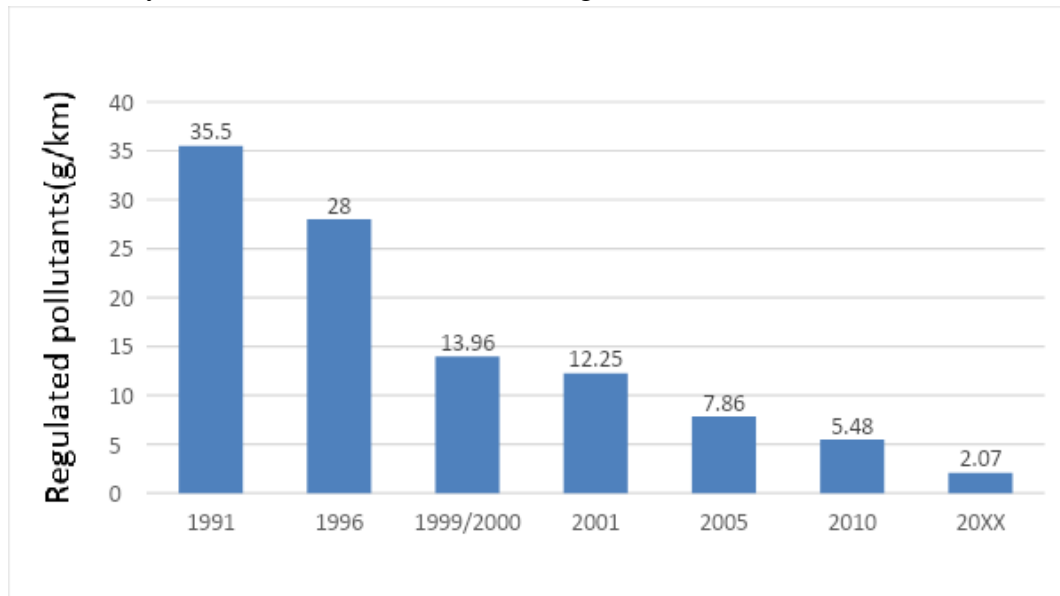


Figure 2. Regulated pollutants in (g/km) from 1991 (year of enforcement of first emission norms) to 20XX (year of enforcement of Bharat Stage VI norms in future) for petrol cars.

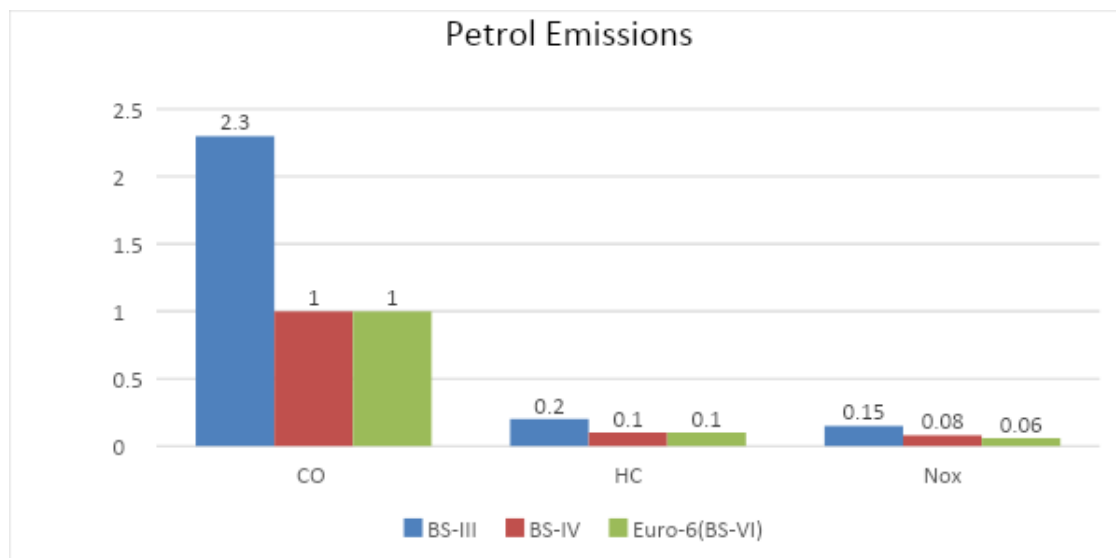


Figure 3. Petrol emissions in g/km during the enforcement of emissions norms- Bharat Stage III, Bharat Stage IV and estimation of emissions during Bharat Stage VI .

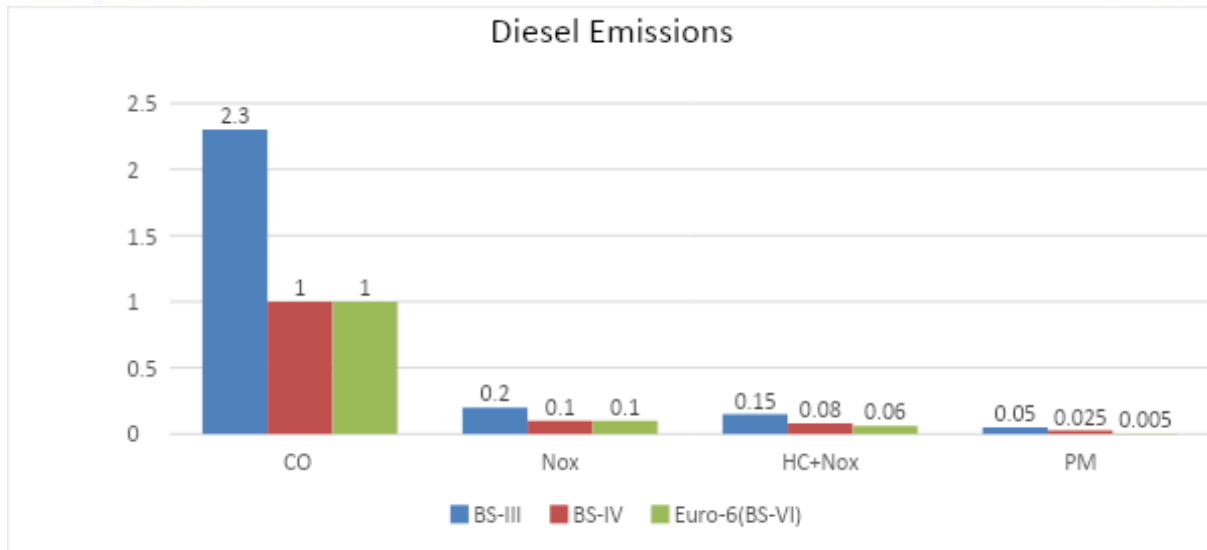


Figure 4. Diesel emission in g/km during the enforcement of emissions norms- Bharat Stage III, Bharat Stage IV and estimation of emissions during Bharat Stage VI .

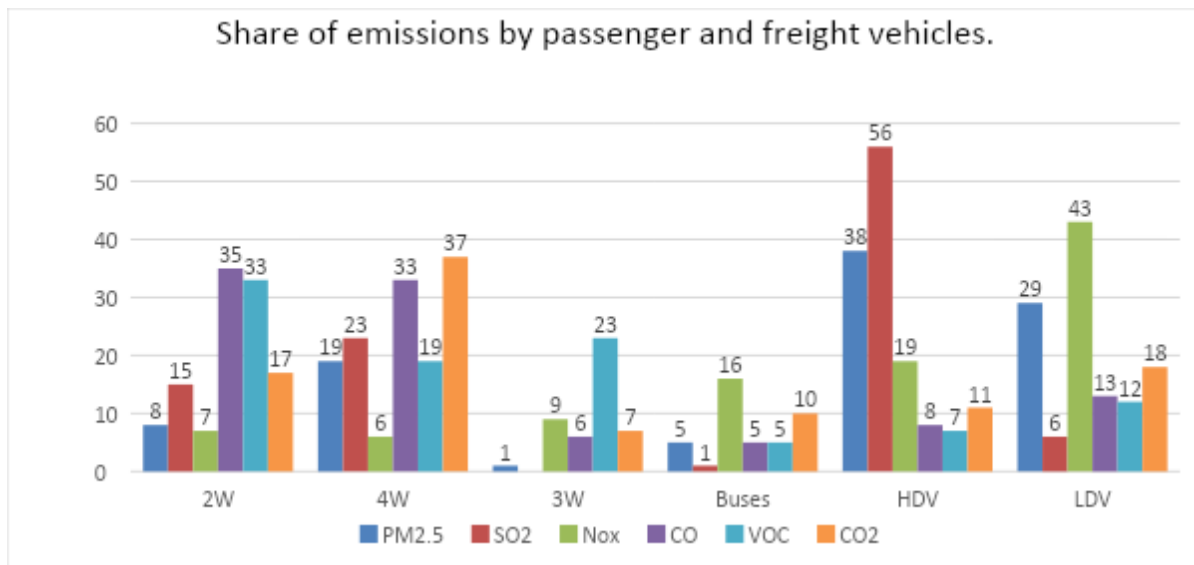


Figure 5. Share of different types of vehicles in the emissions of PM2.5, SO₂, NO_x, CO, VOC and CO₂ in per cent as on January 2012

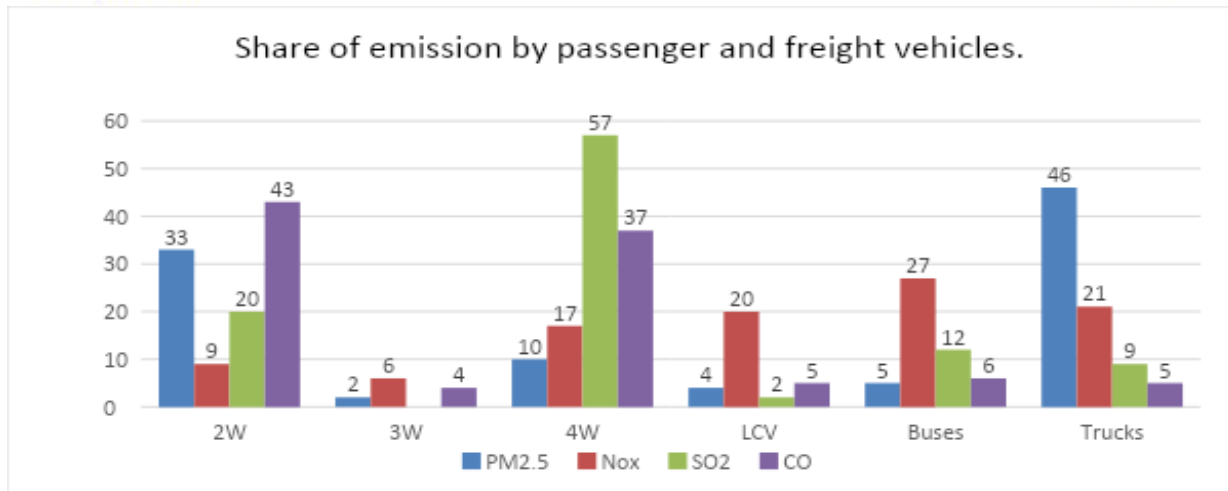


Figure 6. Share of different types of vehicles in the emissions of PM2.5, SO₂, NO_x, CO, VOC and CO₂ in per cent as on January 2016.

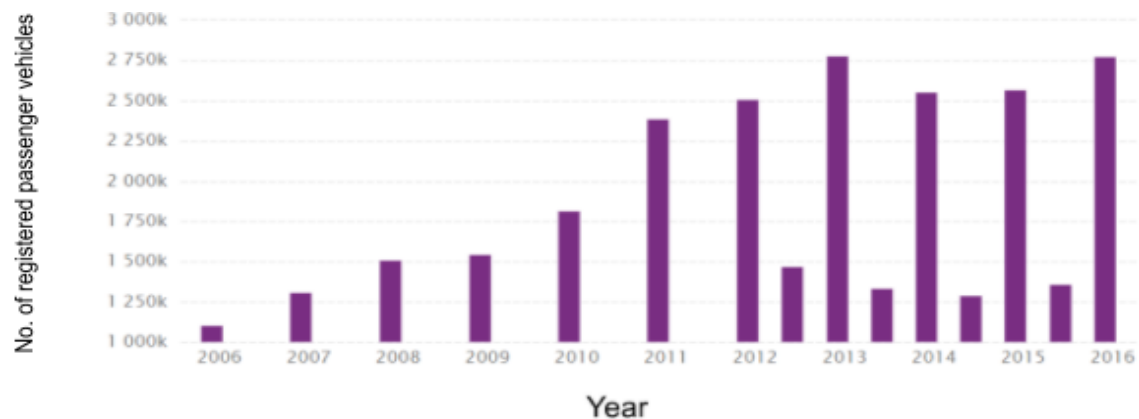
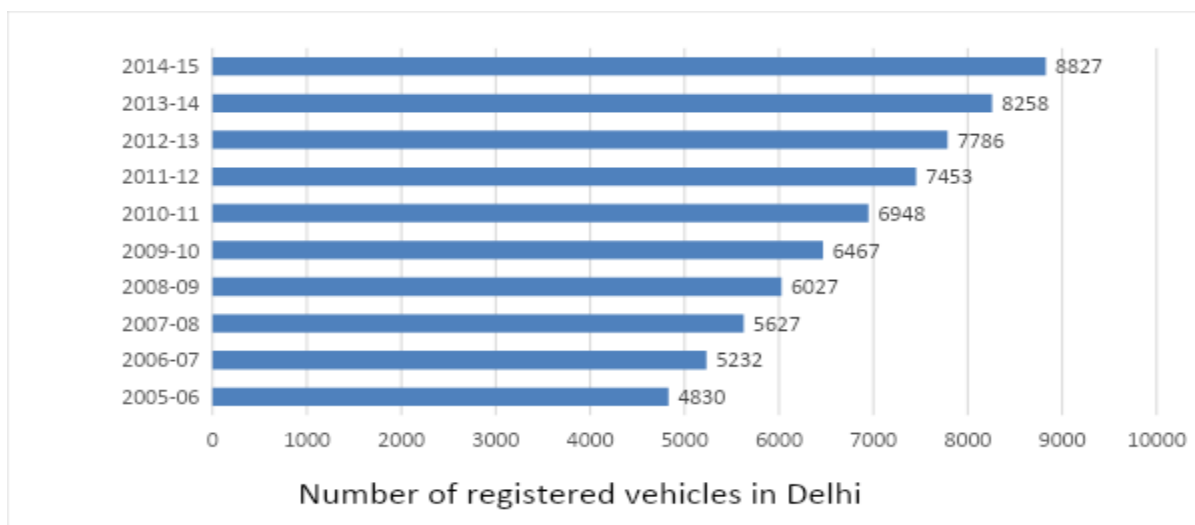


Figure 7. (a) Number of registered vehicles in Delhi from 2005 to 2015 in thousands.

(b) Number of registered passenger vehicles in India from 2005 to 2015

EMISSIONS STATISTICS

Figure 5 and 6 show that the percentage share of emissions in the passenger and freight vehicles has changed over the 4 years from January 2012 to January 2016. Evidently, 2, 3, 4W passenger vehicles and busses have shown to increase their share of emissions while the commercial trucks have shown an improvement. This change can be owed to the strict Bharat standards for pollution control and the banning of diesel engines above 2000cc. Figure 7 clearly indicates the rapid increase in the number of vehicles. Figure 7(a) gives a visualization of the total number of vehicles while Figure 7(b) shows data for passenger vehicles. In the year 2005-2006, nearly 23% of total vehicles were passenger vehicles which rose to 35% in 2013. After 2013 the number of passenger vehicles showed a flat curve, but this can be explained by saturation of demand. An important concern with this increase in the percentage of passenger vehicles is that the passenger vehicle segment seems to contribute highly to the percentage of emissions as explained above. This can be a worrying factor for later years if proper steps are not taken.

EMISSION NORMS ENFORCED IN DELHI (1991-2020)

1991- The first vehicular emissions norms came into existence. Ideal CO Limits are set for petrol engines and mass emission norms for gasoline vehicles.

1992- Mass emission norms on diesel vehicles.

1994- Norms are enforced to reduce the amount of lead in one litre of petrol to 0.15g.

1995- Mandatory fitting of catalytic converters in new passenger cars.

1996- The second set of emission norms came into existence and were enforced. The measures that were taken to curb emissions are as follows: -

1. Fuel quality was notified under the Environmental Protection Agency for the first time.
2. Diesel Sulphur percentage in one litre of petrol was reduced to 0.5%.
3. Gasoline benzene percentage in one litre of petrol was reduced to 5.0%.

1997- Norms are enforced to reduce the percentage of diesel Sulphur in one litre of petrol to 0.25% from 0.5%.

1998- Cold start norms are introduced. The measures that were taken to curb emissions are as follows: -

1. Gasoline benzene percentage in one litre of petrol was reduced to 3.0% from 5.0%.
2. Lead was phased out of the petrol that earlier was 0.15g/litre of petrol.
3. Commercial vehicles more than 15 years old were phased out in December 1998.

1999- The measures taken to curb emissions are as follows: -

1. Usage of unleaded petrol began in Delhi.
2. Only Non-Commercial vehicles complying with EURO-I norms were registered in NCR.

2000 - India Stage 2000 (Euro I) are enforced. The measures taken to curb emissions are as follows: -

1. Diesel Sulphur percentage in one litre of petrol reduced to 0.05%.
2. Gasoline benzene percentage in one litre of petrol reduced to 1.0%.
3. The maximum percentage of Gasoline Sulphur is set to 0.05%.
4. Low smoke 2-T oil introduced.
5. Expansion of Compressed Natural Gas (CNG) supply outlets from 9 to 80.
6. Only non-commercial vehicles complying with EURO-II Norms to be registered in NCR.

2001 - Bharat Stage-II norms (Euro II) are enforced in all the metropolitan cities. The measures taken to curb emissions are as follows: -

1. CNG and LPG were permitted to be used as auto fuels in January 2001.
2. Replacement of all post-1990 auto-rickshaws and taxis with new vehicles that operated on clean fuels by 31 March 2001.
3. Catalytic converters made mandatory for all four-wheeled petrol-driven vehicles.
4. Entire city bus fleet (DTC & Private) converted to single fuel mode on CNG.
5. Augmentation of public transport to 10,000 buses (from existing 6,600 buses).

2002 - Delhi Metro began its operation in December 2002. It is one of the most significant initiatives taken by the Delhi Government to reduce the usage of vehicles and encourage people to travel green and reduce pollution.

2003 - Enforcement of Bharat Stage-II norms for 11 major cities.

2005- Bharat Stage-III norms (Euro 3) are enforced in 11 major cities. The measures taken to curb emissions are as follows: -

1. Bharat Stage II Emission Norms enforced on 2 & 3-Wheelers from April 2005.
2. Stricter norms enforced whereby the percentage of Sulphur in Diesel and Petrol was reduced to 0.035%.

2006 - Usage of CNG for lightweight vehicles begins.

2008 - Bharat Stage-III Emission Norms for 2 & 3-Wheelers were preferably enforced from 1 April 2008 and not later than 1 April 2010.

2010 - Bharat Stage-IV norms (Euro IV) are enforced in thirteen cities namely National Capital Region and the cities of Mumbai, Kolkata, Chennai, Bangalore, Hyderabad including Secunderabad, Ahmedabad, Pune, Surat, Kanpur, Agra, Sholapur, and Lucknow in April. The measures taken to curb emissions are as follows: -

1. Bharat Stage III Emission Norms enforced for 4-wheelers for the entire country.
2. Sulphur content in diesel and petrol further reduced to 0.005%.
3. 2500 low floor CNG buses introduced in Delhi.

2011 - Delhi Metro is spread across 190 km and operationalized which in turn, led to reduction the number of vehicles on the roads driven on conventional fossil fuels, creating pollution. A lot of daily commuters start travelling green by commuting via Delhi Metro, leading to reduction in pollution

2014 - ECMA organizes a Free Pollution under Control Check (PUC) Programs as a part of Corporate Social Responsibility (CSR) to promote Clean Air and Pollution Free Environment. The program is carried out for 15 days at BPCL petrol pump and another fifteen days at HPCL, New Delhi.

2015 - The measures taken to curb emissions are as follows: -

1.The Delhi government proposes the odd-even rule wherein cars with odd-number functional on odd dates and cars with even-number plates functional on even dates. To augment the public transport facilities and provide hassle-free passage during the odd-even rule, the government said it would add 1,000 more buses in three months. Also, 9,000 CNG contract carriages come into existence to strengthen the public transport facility of the capital before its implementation.

2.The Supreme Court bans the registration of luxury SUVs (Sport Utility Vehicle) and diesel cars above 2000cc in the national capital. Diesel cars are believed to be a major source of vehicular emissions.

3.The green cess on commercial vehicles entering Delhi is hiked by the Supreme Court (SC) by a whopping 100%. The SC-appointed Environment Pollution Control Authority (EPCA) directs the Delhi government to install boards notifying the new cess in 125 toll booths across Delhi.

4.The National Green Tribunal (NGT) asks the central and state government not to buy diesel vehicles for its personnel. It also asks public administration departments and municipal bodies to take efforts to gradually phase out diesel vehicles.

2016 - The measures taken to curb emissions are as follows: -

1.The government proposes the entire city to go car-free on the 22nd of January.

2.The Supreme Court bans the registration of luxury SUVs and diesel cars above 2000cc on a trial basis and doubled the Environmental Compensation Charge (ECC) on all commercial vehicles transiting through Delhi to prevent non-Delhi bound vehicles from entering the city. The money thus collected is proposed to be used to strengthen the public transport facility in the capital city to pave the way to hassle-free commuting across the city.

3.The government also issues an order that all taxis such as Uber must run on compressed natural gas by March.

4.The Delhi Government implements the odd-even rule in two different phases for 15 and 16 days in phase 1 and phase 2 respectively. The first phase begins on January 1, 2016, and ends on January 15, 2016. The second phase begins from April 15, 2016 and ends on April 30, 2016. The idea is to reduce congestion as well as to reduce pollution resulting from vehicular emissions.

2020 - If sources are to be believed Bharat Stage-VI Norms (Euro VI) will be enforced in the capital city in April 2020. The changes in the petrol and diesel emissions that to be permitted under the new norms are as follows: -

1.Petrol Emission Norms- The amount of permitted emissions will be: -

CO: 1.00 g/km, HC: 0.10 g/km, NOx: 0.06g/km, PM: 0.005g/km

2.Diesel Emission Norms- The amount of permitted emissions will be: -

CO: 0.50 g/km, NOx: 0.06 g/km, HC+NOx: 0.17g/km, PM: 0.005g/km

IMPROVEMENTS IN THE ENGINE'S TECHNOLOGY AND DESIGN AND ITS IMPACT ON VEHICULAR EMISSION

- 1.The four-stroke engine cycle in internal combustion (IC) engine: These engines are more fuel-efficient and help in reducing emissions as compared to the two strokes engines. Lubricating oil needs to be mixed to the combustion fuel in a 2-stroke engine to keep it running. The burning of this lubricating oil releases unburned HC particles and other pollutants. Such an arrangement of mixing the lubrication oil to the fuel is not required in a 4-stroke engine making it much cleaner than its 2stroke counterpart.
- 2.Forced Induction: Three things are required by the engine to produce motion namely - fuel, air and heat. Allowing more air into an engine will increase the power supplied by the engine. To do so, forced induction is one of the widely used techniques. Through this technique, we can produce more force with a small engine size. Small engine size means less fuel intake which further leads to a decrease in the emissions.
- 3.Fuel Injection: Increasing fuel injection pressure has helped in improving the fuel atomization, as compared to the previously used carburettor, which in turn has helped in improving the combustion process, resulting in a decrease in the HC, CO and PM emissions.
- 4.Direct Injection: Direct injection is another step in the refinement of the improvements made by fuel injection. Fuel in the direct injection system is sprayed directly into the combustion chamber rather than in the intake manifold as done in the fuel injection method. This allows one step i.e. fuel injection to be skipped making the engine more efficient by delivering more power and lesser fuel consumption.
- 5.Aluminum engine blocks: Replacing the iron engine components by aluminum, helps in reducing vehicle's weight which in turn helps in increasing fuel efficiency and less vehicular emissions.
- 6.Variable Valve Timing: There are many instances like hard acceleration when the flow of air inside the engine needs to speed up to provide required acceleration. Conventional engines could not provide the feature of variable airflow according to one's needs. But with the advancement in vehicular technology, many companies have emerged with different technologies to provide variable valve timing that not only provides better fuel economy but also ensures flexible power delivery. Both features contribute to lesser emissions. Honda, Toyota and BMW are among the manufacturers who have successfully implemented Variable Valve Timing in their engines.
- 7.Clean Diesel: The modern diesel engines made by the manufacturers are clean, powerful and quite fuel-efficient as compared to those in the 1980s. The new engines use low-Sulphur diesel fuel that not only makes these engines higher fuel efficiency and torque but also helps in eliminating particulate matter and ensure reduced emissions.

8. Hybrid Engines: With the advancement in technology, these days cars are installed with hybrid engines. Hybrid engines have the provision of switching their fuel type from electricity to petrol or diesel. An electric motor is combined with a traditional petrol or diesel engine to attain high fuel economy, reduce the usage of petrol or diesel which in turn results in lesser emissions and reduces pollution to a great extent.

FIELD STUDY

To get a better insight of the emission norms and vehicular technologies that have affected the vehicular emissions, we visited ICAT (International Centre for Automotive Technology) and interviewed some officials on the issue. The transcript of the interview is given below.

1.Q. Which vehicle manufacturing companies have done considerable improvements in their engine design and technology to reduce emissions?

A: Naming a few companies would not be the right answer. In the current scenario, all the automobile companies are trying to do efforts to improve their existing technology and bring about some changes in their engine design because change is what fascinates the consumers the most. Also, changes in the engine design need to be carried out by all the companies to make vehicles in compliance with the upcoming Bharat Stage VI norms.

2.Q. What will be the future developments and changes in the engine design and technologies that can ensure minimum vehicular emissions?

A: The future might witness many alterations and developments in the engine design. Downsized engines offering big thrust would be one of those changes. Engines will gather power by utilizing alternative forms of energy like ethanol, hydrogen, petrol, electricity. Automobile companies will face a big challenge to improve the engine design, adapt new technologies and at the same time taken into consideration the overall cost factor.

3.Q. What is the reason for not enforcing Bharat Stage -V norms and making efforts to directly enforce Bharat Stage VI norms?

A: Other countries are quite ahead in comparison to India in terms of vehicular technologies and emission norms. In such a scenario, implementing Bharat Stage-V norms will not only make our country appear outdated but will also make it a dumping ground where automobile companies can sell off their vehicles with outdated technologies. Thus, implementation of Bharat Stage- VI norms is what is the need of the hour.

4.Q. What do you think will be the impact of the enforcement of Bharat Stage -VI norms on vehicular emissions?

A: Bharat Stage-VI norms formulation and future implementation have quite been resisted by many automobile manufacturers for various reasons even before their implementations. One of the most probable reasons is the strict regulations on emissions which makes it difficult for manufacturers to produce the vehicles with new technology and engine design that ensures lesser

emissions at the same cost at which they are manufacturing the vehicles now. It clearly indicates that Bharat Stage-VI norms will have a huge positive impact on emissions.

5.Q. What extra infrastructure does the vehicle manufacturing companies and the monitoring agencies need to employ to ensure the effective implementation of Bharat Stage VI norms?

A: Simulation techniques need to be employed by labs to measure pollution levels by newly developed engines and fuels. New machinery and technologies of Rupees 80,000 crores worth need to be acquired by the oil companies to carry out desalination of crude oil to much finer levels. Automobile manufacturers need to spend more money on R&D to innovate vehicles that run on alternate fuels like hydrogen, biogas, methanol, ethanol etc.

6.Q. The Indian Government is planning to gradually replace all the diesel engine vehicles with petrol-driven and environment-friendly fuel (CNG, LPG etc.) driven vehicles. Do you think it is possible to do so? If it is done, what would be its implications?

A: Replacing all the diesel engine vehicles is certainly not an impossible task but it would require time. It is not something that can be done in a day. Nationwide, there are so many diesel engine vehicles that are being used by the Indian Government. Thus, this goal can be achieved gradually but not immediately. Once this goal will be achieved, it will surely have a huge impact on the geography of the emissions across the country.

7.Q. In the current scenario, electric cars manufacturers are unable to attract much attention. What could be the probable reasons behind it?

A: Car manufacturers have produced electric cars for the heck of producing them. The existing electric cars don't offer any special features that can really attract people towards them. Thinking from a common man's point-of-view, all he wants in a car is good internal and external design, reliability, performance and value for money. Take the case of Mahindra e2o. The car costs around 7 Lakh Rupees but lacks interior and exterior design runs only 120 km on one charge and lacks the thrust that one generally experiences on accelerating. Not a single feature being offered by this car may ever compel anyone to buy it. People would rather buy another car at the same or less cost that will offer high performance, reliability and will have a better interior and exterior design. Moreover, people are more concerned about the comfort of transit which an existing electric car like e2o doesn't offer.

8.Q. What can you predict about the future of electric cars? Would there be a considerable rise in their sales? What all improvements in design and technology should be taken into consideration to boost their sales?

A: Right now, it is very hard to predict the future of electric cars. There would be a rise in their sales once the companies manufacturing such cars will offer high performance in terms of covering more distance in one charge and reliability by opening charging centers in huge numbers so that people might not worry about charging the car's battery if they are going for a long journey. Also, electric car's batteries are made up of some precious metals that lead to a hike in their prices. In such a situation, reduction in the cost of these cars can only be achieved if

manufacturers try to find ways to reduce the cost of the battery and other components by finding some alternate means to manufacture these components which might require quite a lot of time.

CONCLUSION

Four-wheel passenger vehicles have come out to be a major concern in terms of vehicular emissions. From the year 2012 to 2016, the percentage contribution of 2w and 4w vehicles share of emissions has shown a staggering increase. There has also been an increase in the number of registered passenger vehicles, implying that this segment may become a serious contributor to the pollution index soon. Major contributors to this vehicular pollution are associated with improper usage of available resources such as the use of CNG instead of petrol and diesel. Regular maintenance and timely servicing of a vehicle can help in curbing unnecessary pollution generated from ill-maintained or old vehicles. What we can conclude through this report is the fact that the government cannot reduce air pollution without getting any support from the citizens. From 1991 the government has been bringing out reforms to curb the pollution, from regular updates on Bharat Standards by putting ban on obsolete and harmful diesel engines and introducing unleaded petrol. Introducing Delhi Metro (2002) and compulsory usage of CNG for lightweight vehicles (2006) has started to show a difference now. Introducing odd-even rule in Delhi and providing free PUC checks was a very smart initiative to ensure vehicles passengers running on the road are operating under pollution norms and the number of vehicles are also less and pollute less.

Vehicle technology has matured enough to provide high-quality engines which provide the same user experience as before, without compromising on pollution standards and costs. Vehicles with these updated technologies should be provided to the customers as soon as possible. An investment here will reap benefits to not only the environment but also can be really profitable. Use of hybrid and fully electric vehicles is the need of the hour. While the government should encourage its citizens to go electric it must also introduce measures and incentives for people and businesses for the same mission. This must also be coupled with the development of extracting more energy from renewable resources and reducing the dependency on fossil fuel for the generation of electricity. India is a developing country with the sharpest minds, in the world along with large availability of renewable resources and a large green cover. With the right use of resources and smart adaptation of pioneering technologies, India can transform into the greenest country in the world in terms of vehicular emissions, and thereby setting up an example for the rest of the world to follow.

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