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Status of air quality and respiratory health in Delhi

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Abstract- ***The paper analyses air quality trends in the city of Delhi over the decade. Pollutant levels have gone up again after a brief period of marginal decline. A review of activity levels across different contributing sectors is carried out. Vehicles have doubled in the last decade and have contributed to increase in pollutant levels. The effectiveness of interventions taken to reduce air pollutant concentrations is evaluated. There was a marginal decline of pollutants due to introduction of cleaner fuels, vehicles and other relevant measures. The effect of air pollutant concentrations is been assessed over the respiratory health in the city which also shows increase in mortalities due to respiratory disorders during the last few years. The paper finally suggests additional measures for control of air pollution in the city.***

Keywords: Air pollution, Health, Emissions, Delhi

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Key messages

Air quality is deteriorating in Delhi which has implications on respiratory health of the residents. Some interventions have been taken by the government; however, many more will be required to get the air quality in prescribed standards.

I. Introduction

Air pollution has been widely linked with severe health impacts [(1)], ecology [(2)], buildings [(3)], and agricultural productivity [(4)]. In India, about 6.2 lakh mortalities are attributed to ambient air pollution [(5)]. Most of the Indian cities are dealing with severe deterioration of air quality.

Delhi, is the capital of India, is almost like a country in itself with hosting more than seventeen million population, more than seven million vehicles, power plants, and industries. The city has seen tremendous migration of population from other states and has also shown spectacular economic growth. However, that has come with the brunt of environmental problems. Rising air pollution levels have been one of those concerns. This paper discusses the major sources of pollution in the city, the trends of air pollutant concentrations over the last decade, its impacts over human health, and the interventions taken for its control.

II. Major Causal Factors

The major sources of air pollution in Delhi include transport, domestic, power, and industrial sectors. The growth of these sectors has been fuelled by rapidly growing population and economic growth of the city. While, the population of Delhi has grown by 20% since 2001, the net state domestic product of Delhi has increased by almost three times. Population of Delhi has grown at a decadal growth rate of 47% during 1991-2001 and has now further grown to 168 lakhs in 2011[(6)]. The unnatural growth of population in Delhi has put unprecedented demands on the natural resources and infrastructure. Hence, the power consumption, demands for mobility has also increased multi-folds. Motorised vehicles which are the important source of air pollution have grown from about 34 lakhs in 2001 to 77.7 lakhs in 2013 [(6)]. The distribution shows that about 95% vehicles are privately owned (cars and two-wheelers), while public transport i.e. buses are just 1% of the total vehicular fleet. Hence, Delhi shows about 400 registered vehicles per thousand population. Based on the sales data for 2012-13, there are about 931 vehicles registered on a daily basis[(6)]. Apart from vehicles, there are other sources of air pollution which includes industries, power plants and domestic sources.

Although, industries have majorly been relocated to outskirts of Delhi, there are specified industrial zones which house the factories for food, textiles, chemical, metal, non-metallic minerals, etc. The growth in population and growing use of electrical appliances has led to growth in power demand of the city. Installed capacity for power generation in Delhi, which was nearly 200 MW in 1985, has gone upto1059 MW in 2012. The domestic sector has the largest

share (81%) in the total power consumption in the city. In 2012, more than 90% households had the access to LPG, while 5% and 3% households are still dependant on kerosene and firewood for cooking [6].

Analysing the overall fuel consumption, diesel is the primary fuel used in Delhi (1037 thousand tonnes in 2012-13), despite the fact that buses and autos have now been fully converted to CNG (compressed natural gas). Consumption of petrol and LPG has also increased, while Kerosene consumption is reduced due to penetration of LPG. The major sources and their broad activity levels in the city are presented in Table1.

Table 1: Major sources and their broad activity levels [6,7]

Data	2001	2012
Area	1483 km^2	1483 km^2 (75% urban)
Population	13.8 million	16.8 millions
Economy Per capita income	Rs40,337 Current Prices	Rs 1,48,608 Current Prices
Vehicles	34.5 lakhs	74 lakhs (Cars :23 lakhs, 2-w: 46 lakhs, Autos: 0.88, Taxis: 0.69 lakhs, Buses: 0.64 lakhs, Trucks : 2.28 lakhs)
Industries	Index of production : 103.28	Index of production : 123.21
Power plant generation (MW)	Installed : 602 MW	Installed : 1059 MW

III. Contribution of Sources

Source apportionment studies have been conducted in Delhi to ascertain the contribution of different sources towards prevailing air pollutant concentrations. UNDP/WB Energy Sector Management Assistance Program [8] found that the three

major sources of fine particulate air pollution are vehicle exhaust, re-suspended road dust, and solid fuels, especially in cities with cold winters. Figure 1 shows the contribution of various sources to ambient PM2.5 (fine particulate less than 2.5 microns) concentrations in the city.

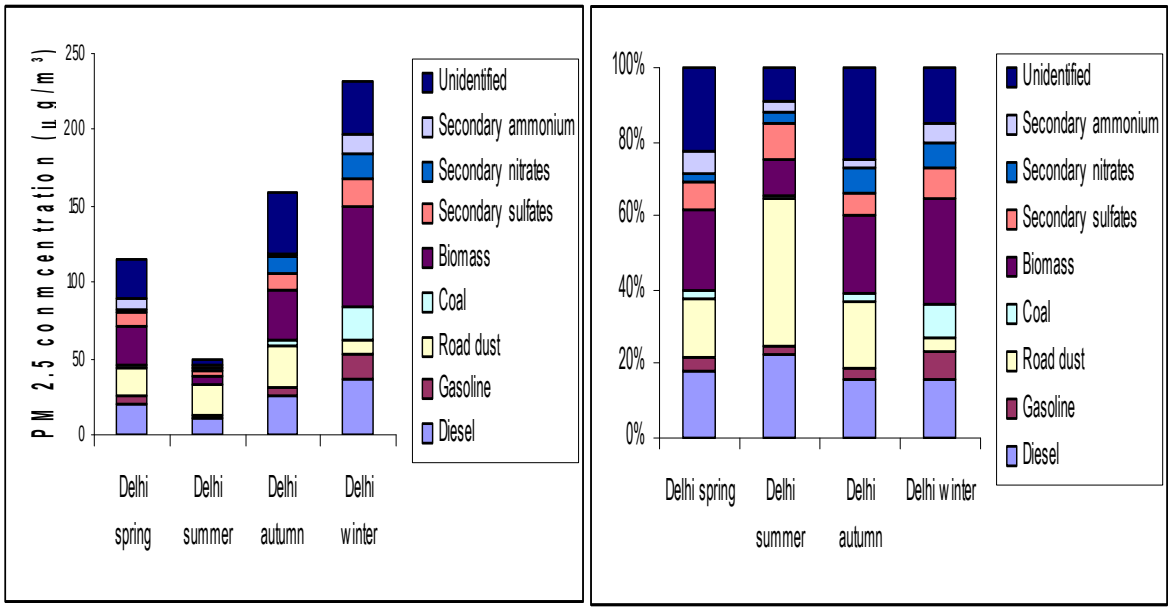

Fig. 1: Results of source apportionment study for PM 2.5 conducted in Delhi[8]

It can be observed that higher PM2.5 concentrations are observed in winters when lower wind speeds are observed. Also, the source contributions change during different seasons. In summers the contribution of wind-blown re-suspended road dust becomes high, while in winters the anthropogenic sources dominate.

IV. State of air quality in Delhi

Under the National Air Quality Monitoring Program (NAQMP), air quality is monitored at 9 stations in Delhi, and three criteria air pollutants – sulphur dioxide (SO2), oxides of nitrogen (NOx), and respirable suspended particulate matter (RSPM) – are regularly monitored and analysed. The trends of different air pollutant annual average concentrations observed in the city are presented in Figure 2a, 2b, 2c, 2d.

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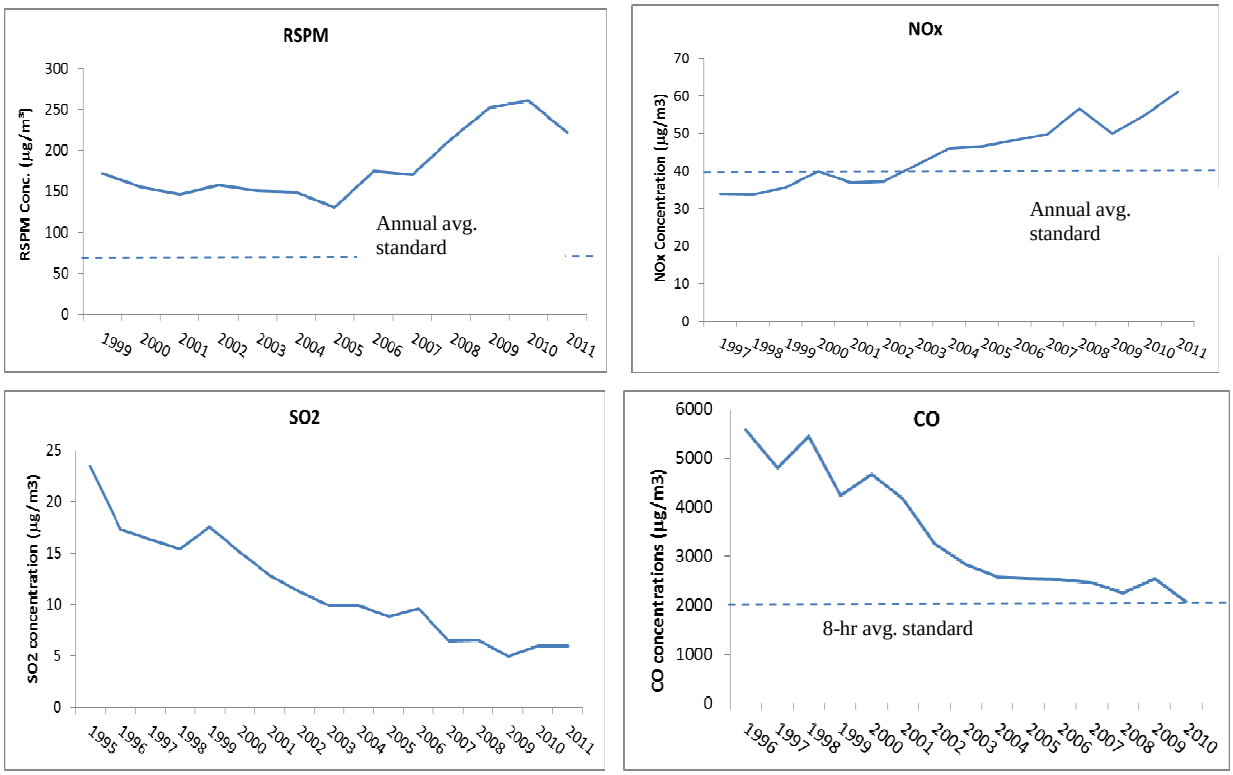

Fig. 2: a,b,c,d Ambient air quality trend of RSPM, NOx, SO_2, and CO in Delhi for the period 1995-2011[9-25]

* CO results for ITO station only, RSPM monitoring started in 1999 only.

The PM concentrations have violated the standards consistently over the whole decade. While on one hand there is an increasing trend observed in NOxconcentrations, SO_2 and COconcentrations have shown a marked decline. The increase in NOx can be attributed to growth of vehicles and more specifically of diesel driven vehicles. The reduction in sulphur content of different liquid fuels used in the city has led to reduction of SO_2 concentrations. Introduction of tighter CO standards for gasoline vehicles have somewhat controlled CO concentrations in the city.

V. Impacts

Air pollution, is known to have wide ranging impacts over human health, agricultural productivity, materials and visibility, etc. There are many studies which link the pollution levels in the city with the health outcomes. A study in 1997 showed that a significant relationship

between mortality for ages 5-64 years and particulate matter concentrations. The study concluded a 2.3 % decrease in deaths corresponding to a 100 microgram reduction in PM concentrations [(1)]. However, it was found that in Delhi, the more impact is visible on the age group of 15 to 44 years pointing towards higher number of life-years lost in Delhi. Another study correlated the daily pollutant concentrations with the hospital visits at AIIMS, New Delhi for cardio-respiratory problems and concluded that population residing in higher polluted regions have the higher risk of respiratory problems[(26)]. They showed that Emergency room visits for asthma, chronic obstructive airway disease (COAD) and acute coronary events increased by 21.3%, 24.9% and 24.3%, respectively due to higher pollutants concentrations. The correlation between the ambient air pollution and chronic respiratory morbidity in Delhi is also established [(27)]. The vitamin D deficiency in children living in polluted localities is also found in a study [(28)]. On the other hand, the finding have also been documented the effects of air pollution on the eyes of people residing in Delhi[(29)]. Table 2 shows the pollutant wise impacts of different air pollutants documented in various studies.

Table 2: Health effects of different air pollutants

Pollutants	**Effects**
Nitrogen dioxide (NOx)	Bronchitis in asthmatic children. Reduced lung function growth
Particulate Matter ($PM_{2.5,}$ PM_{10})	Cardiovascular and respiratory diseases, lung cancer, ALRI (acute lower respiratory infection), COPD (chronic obstructive pulmonary disease).
Carbon monoxide (CO)	Reduces the oxygen carrying capacity of blood, causes headaches, nausea, and dizziness. Can lead to death at high levels
Sulphur dioxide (SO2)	Affects respiratory system and lung function. Coughing, mucus secretion, asthma and chronic bronchitis. Causes acid rain.
Lead	Affects intellectual development of children, and at very high doses poisoning, brain and organ damage can occur.
Benzene	Exposure over a long time can lead to cancer

1, 3 Butadiene	Exposure over a long time can lead to cancer.
Ozone	Breathing problems, asthma, reduce lung function. Ozone is one of the most damaging pollutants for plants.

Figure 3 shows the percentage of deaths caused due to respiratory diseases in Delhi over the period of 1998-2012. The figures somewhat show the trend shown by the PM concentrations in Figure 2a. The reduction is observed in the years of 2002-2006, but then there is again a rise in mortalities in the recent years. Some of it can be subjectively attributed with similar rise in RSPM concentrations in last few years. However, this is to be noted that respiratory disorders can not only be directly correlated with air pollution, as there are other confounding factors like smoking.

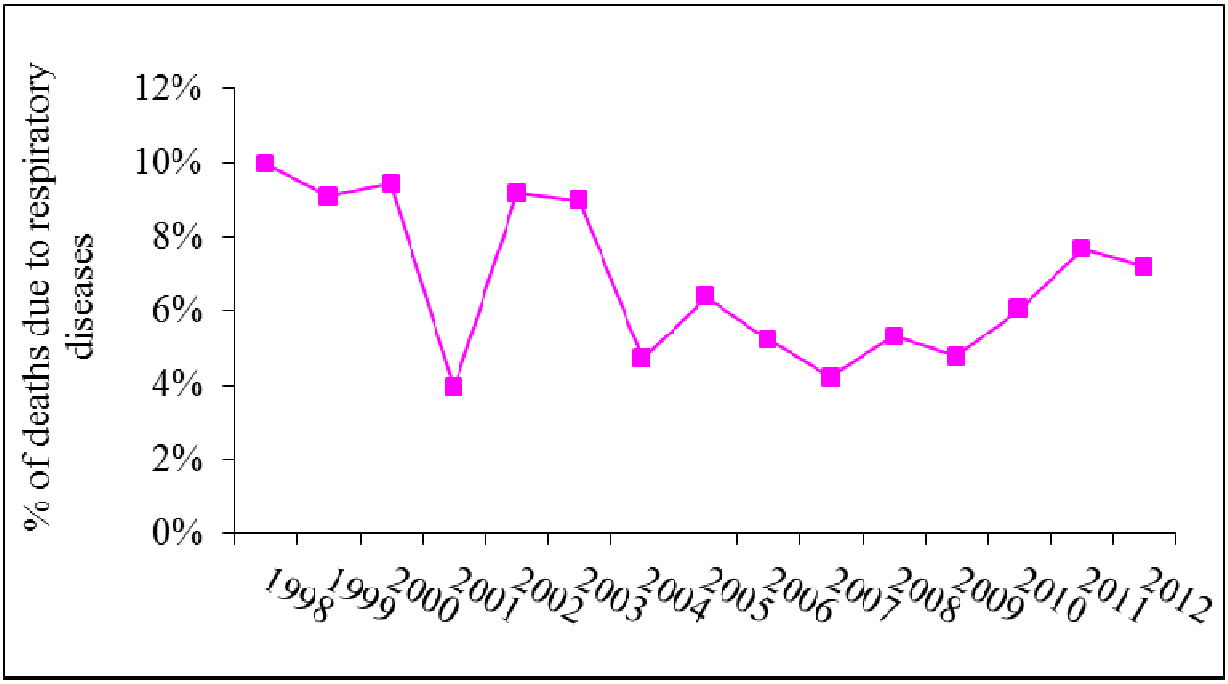

Fig.3: Percentage deaths due to respiratory diseases in Delhi [6,7]

VI. Interventions taken in past

Due to pressures from civil society and judiciary many interventions have been taken in Delhi for control of air pollution in the city. The interventions are chronologically listed in Table3.

Table 3: Chronological list of measures taken for control of air pollution in Delhi

Year	Intervention(s)
1994-95	Introduction of catalytic converters and unleaded petrol
1996-2010	Sulphur reduction program from about 0.5% in 1996 to 50 ppm in 2010. Benzene reduction program.
1996-2001	Closure and relocation of hazardous industries
1998-99	Ban on old commercial/transport vehicles older than 15 years
2000-2010	Introduction of advanced vehicular emissions and fuel quality norms (Bharat Stage II- IV) Beneficiated coal for power plants
2001-2003	Introduction of gaseous fuels (CNG) for buses, autos and taxis
2005	Completion of Metro rail (Phase-I)
2006-2013	Bus Rapid Transit (BRT) projects Increase in CNG vehicles Enhancement of Metro networks Conversion of power plants to gas based Strengthening of PUC (pollution under control) check systems

The interventions had an impact over the prevailing pollutant concentrations. Reduced sulphur content has led to reduction of SO2 concentrations. The use of catalytic converters, shifting two –wheelers technology from 2-stroke to 4-storkehas reduced CO concentrations. RSPM has gone down marginally when some interventions (like closure of industries, banning of old vehicles, newer vehicle and fuel standards, use of beneficiated coal in power plants, and introduction of CNG) were made. However, the benefits were totally negated by the rapid growth of vehicular fleet. A shift towards diesel driven vehicles and from small to bigger cars is also a contributing factor. NO_X concentrations have remained unaffected by the interventions and have risen with the growth in diesel driven vehicles.

VII. Conclusions

Air pollution is a serious concern for a city like Delhi where not only the pollutant levels are high but also the population which is exposed to them is dense. Due to introduction of several measures, the air quality in the city improved marginally in the middle of the last decade. However, with growing activity levels, the pollutant concentrations have gone up again and even surpassed the previous levels. It is to be noted that the interventions had been successful in reducing emissions and

concentrations of SO2 and CO, but PM and NOx concentrations have increased tremendously over the last few years. The standards for PM have been violated by a margin of 3-4 times. NOx concentrations have also now above the prescribed limits.

Many research studies have linked air pollution with sever health impacts. The statistics of mortalities due to respiratory disorders in Delhi also show a recent increase in last few years. However, all this cannot be solely attributed to air pollution as there are other confounding factors like smoking.

Considering the growth patterns observed in the city and its projected future, significant measures are required to be taken for control of air pollution in the city. They may include

1) Advancement of vehicular emissions and fuel quality norms to BS-V and BS-VI levels.
2) Strengthening of Inspection and Maintenance programme to control emissions from in-use vehicles
3) Fleet modernisation – replacement of old commercial vehicles
4) Further enhancement and improvement in public transport systems based on buses and Metro.
5) Control of pollution from satellite town around Delhi
6) Control of emissions from coal based power plants
7) Enhancement of monitoring network and modelling capabilities for better prediction
8) Carrying out regular research studies to tweak the strategies for control
9) Regular cleaning of roads to reduce road dust emissions
10) Effective adherence to norms while construction project for control of dust

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