CME

"Air pollution in Delhi: Its Magnitude and Effects on Health"

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ABSTRACT

Air pollution is responsible for many health problems in the urban areas. Of late, the air pollution status in Delhi has undergone many changes in terms of the levels of pollutants and the control measures taken to reduce them. This paper provides an evidence-based insight into the status of air pollution in Delhi and its effects on health and control measures instituted. The urban air database released by the World Health Organization in September 2011 reported that Delhi has exceeded the maximum PM10 limit by almost 10-times at 198 $\mu g/m3$. Vehicular emissions and industrial activities were found to be associated with indoor as well as outdoor air pollution in Delhi. Studies on air pollution and mortality from Delhi found that all-natural-cause mortality and morbidity increased with increased air pollution. Delhi has taken several steps to reduce the level of air pollution in the city during the last 10 years. However, more still needs to be done to further reduce the levels of air pollution.

Keywords: Air pollution Delhi, control measures, health

Pollution refers to the contamination of the earth's environment with materials that interfere with human health, quality of life or the natural functioning of the ecosystems. The major forms of pollution include water pollution, air pollution, noise pollution and soil contamination. Other less-recognised forms include thermal pollution and radioactive hazards. It is difficult to hold any one particular form responsible for maximum risk to health; however, air and water pollution appear to be responsible for a large proportion of pollution related health problems.

Of late, the air pollution status in Delhi has undergone many changes in terms of the levels of pollutants and the control measures taken to reduce them. This paper provides an evidence-based insight into the status of air pollution in Delhi and its effects on health and control measures instituted.

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Status of Air Pollution in Delhi

Delhi (or the National Capital Territory of Delhi), is jointly administered by the central and state governments. It accommodates nearly 167.5 lakh people (2011 Census of India).[1]

Metros across the world bear the major brunt of environmental pollution; likewise, Delhi is at the receiving end in India.

A study funded by the World Bank Development Research Group was carried out in 1991-1994 to study the effects of air pollution.[2] During the study period, the average total suspended particulate (TSP) level in Delhi was approximately five-times the World Health Organization's annual average standard. Furthermore, the total suspended particulate levels in Delhi during this time period exceeded the World Health Organization's 24-h standard on 97% of all days on which readings were taken. The study concluded that the impact of particulate matter on total non-trauma deaths in Delhi was smaller than the effects found in the United States of America, but found that a death associated with air pollution in Delhi caused more life-years to be lost because these deaths were occurring at a younger age.

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A report by the Ministry of Environment and Forests, India, in 1997 reviewed the environmental situation in Delhi over concerns of deteriorating conditions.[3] Air pollution was one of the areas of concern identified in this study. It was estimated that about 3000 metric tons of air pollutants were emitted every day in Delhi, with a major contribution from vehicular pollution (67%), followed by coal-based thermal power plants (12%). There was a rising trend from 1989 to 1997 as monitored by the Central Pollution Control Board (CPCB). The concentrations of carbon monoxide from vehicular emissions in 1996 showed an increase of 92% over the values observed in 1989, consequent upon the increase in vehicular population. The particulate lead concentrations appeared to be in control; this was attributable to the de-leading of petrol and restrictions on lead-handling industrial units. Delhi has the highest cluster of small-scale industries in India that contribute to 12% of air pollutants along with other industrial units.

Vehicular pollution is an important contributor to air pollution in Delhi. According to the Department of Transport, Government of National Capital Territory of Delhi, vehicular population is estimated at more than 3.4 million, reaching here at a growth rate of 7% per annum. Although this segment contributes to two-thirds of the air pollution, there has been a palpable decline compared to the 1995-1996 levels.

The PM_{10} standard is generally used to measure air quality. The PM_{10} standard includes particles with a diameter of 10 µm or less (0.0004 inches or one-seventh the width of a human hair). These small particles are likely to be responsible for adverse health effects because of their ability to reach the lower regions of the respiratory tract.According to the Air Quality Guideline by the World Health Organization, the annual mean concentration recommended for PM_{10} was 20 µg/m^3, beyond which the risk for cardiopulmonary health effects are seen to increase.[4] Major concerns for human health from exposure to PM_{10} include effects on breathing and respiratory systems, damage to lung tissue, cancer and premature death. Elderly persons, children and people with chronic lung disease, influenza or asthma are especially sensitive to the effects of particulate matter. The urban air database released by the World Health Organization in September 2011 reported that Delhi has exceeded the maximum PM_{10} limit by almost 10-times at 198 µg/m^3, trailing in the third position after Ludhiana and Kanpur.[5] Vehicular emissions and industrial activities were found to be associated with indoor as well as outdoor air pollution in Delhi [Table 1].[6-9]

Effects of Air Pollution on Health

A large number of studies in Delhi have examined the effect of air pollution on respiratory functions and the associated morbidity. The most comprehensive study among them was the one conducted by the Central Pollution Control Board in 2008, which identified significant associations with all relevant adverse health outcomes.[10] The findings were compared with a rural control population in West Bengal. It was found that Delhi had 1.7-times higher prevalence of respiratory symptoms (in the past 3 months) compared with rural controls ($P < 0.001$); the odds ratio of upper respiratory symptoms in the past 3 months in Delhi was 1.59 (95% CI 1.32–1.91) and for lower respiratory symptoms (dry cough,wheeze, breathlessness, chest discomfort) was 1.67 (95% CI 1.32–1.93). Prevalence of current asthma (in the last 12 months) and physician-diagnosed asthma among the participants of Delhi was significantly higher than in controls. Lung function was reduced in 40.3% individuals of Delhi compared with 20.1% in the control group. Delhi showed a statistically significant ($P < 0.05$) increased prevalence of restrictive (22.5% vs. 11.4% in control), obstructive (10.7% vs. 6.6%) as well as combined (both obstructive and restrictive) type of lung functions deficits (7.1% vs. 2.0%). Metaplasia and dysplasia of airway epithelial cells were more frequent in Delhi, and Delhi had the greater prevalence of several cytological changes in sputum. Besides these, non-respiratory effects were also seen to be more in Delhi than in rural controls. The prevalence of hypertension was 36% in Delhi against 9.5% in the controls, which was found to be positively correlated with respirable suspended particulate matter (PM_{10}) level in ambient air. Delhi had significantly higher levels of chronic headache, eye irritation and skin irritation.

Table 1: Air pollutants in Delhi

Study and year	Variable	Findings
Goyal *et al.*, 2011[6]	Indoor air pollution in classrooms close to heavy traffic roads	Vehicle exhaust emissions are the only significant contributor to indoor concentrations of $PM_{2.5}$ and $PM_{1.0}$
Kumar *et al.*, 2009[7]	Indoor air lead pollution	Lead loading for floor and interior windowsill samples was 19.7 µg/ft^2 and 75.5 µg/ft^2, respectively
Kumar *et al.*, 2001[8]	Outdoor air	Inhalable particulates in the ambient air increased due to industrial activities up to 320, 168 and 546%, and due to commercial activities up to 406, 198 and 140% in Ahmedabad, Mumbai and Delhi, respectively. There was seasonal variation also
Balachandran *et al.*, 2000[9]	Outdoor air	Coarse PM_{10} - 68.3 ± 17 µg/m^3; fine PM_{10} 71.3 ± 15 µg/m^3. Three major sources were vehicular emissions, industrial emission and soil re-suspension

Several other community-based studies have found that air pollution is associated with respiratory morbidity.[11-13] Numerous studies have reported an association between indoor air pollution and respiratory morbidity.[14-19] Some of these studies have concentrated on children's respiratory morbidity.[15,17,19] Other studies in children have found similar correlations between particulate matter in ambient air and attention-deficit hyperactivity disorder[20] between vehicular air pollution and increased blood levels of lead (a potential risk factor for abnormal mental development in children)[21] and between decreased serum concentration of vitamin D metabolites and lower mean haze score (a proxy measure for ultraviolet-B radiation reaching the ground).[22]

Studies that have examined the compounding effect of meteorological conditions on air pollution found that winter worsened the air quality of both indoor air and outdoor air. They also found a positive correlation between the winter weather and rise in the number of patients with chronic obstructive airway disease in hospitals.[12,16]

There was a relative paucity of studies that measured outdoor air pollutant levels first hand and then tried to objectively correlate them to adverse health effects. However, some studies measured air pollutant levels and found a correlation with health-related events.[17,19]

A time-series study on air pollution and mortality from Delhi found that all-natural-cause mortality increased with increased air pollution.[23] In another study, gaseous pollutants, in spite of being at a level lower than the permissible level, showed more consistent association with respiratory admissions.[24] In a hospital-based study, an increase in emergency room visits for asthma, chronic obstructive airway disease and acute coronary events was reported with an increase in air pollutant levels.[25] These studies are summarized in Table 2.

Control Measures Instituted by the Government of Delhi

The nodal ministry for protecting the environment is the Ministry of Environment and Forests at the Centre and the Department of Environment of the Government of National Capital Territory of Delhi. The Central Pollution Control Board set up in 1974 under the Water Act is the principal watchdog for carrying out the functions stated in the environmental acts, implementation of National Air Quality Monitoring Programme and other activities. The Delhi Pollution Control Board is the body responsible at the state level.

From time to time, the judiciary has taken strong note of the deteriorating environmental conditions in Delhi in response to public litigations. One of the earliest such instances was the judgement passed by the Supreme Court of India to deal with the acute problem of vehicular pollution in Delhi in response to a writ petition filed in 1985. Subsequently, it ordered the shutdown of hazardous, noxious industries and hot-mix plants and brick kilns operating in Delhi.

Vehicular Policy

Control measures so far instituted include introduction of unleaded petrol (1998), catalytic converter in passenger cars (1995), reduction of sulfur content in diesel (2000) and reduction of benzene content in fuels (2000). Others include construction of flyovers and subways

Table 2: Effects of air pollution in Delhi on health

Study and year	Variable	Findings
Siddique *et al.*, 2011[20]	Vehicular air pollution effects in children	Ambient PM10 level was positively correlated with ADHD in children (OR = 2.07; 95% CI, 1.08–3.99)
Rajarathnam *et al.*, 2011[23]	Outdoor air	It was found that every 10 μg/m^3 change in PM_{10} was associated with 0.15% increase in total all-natural-cause mortality
Kumar *et al.*, 2008[15]	Indoor air pollution	Indoor SO_2, NO_2 and suspended particulate effects in children matter levels were high in houses with family history of smoking. Indoor air pollution was associated with respiratory function of children
Kulshreshtha *et al.*, 2008[16]	Indoor air	High levels of indoor airborne pollutants during winter were associated with respiratory problems for women and children.
Jayaraman, 2008[13]	Outdoor air	10 μg/m^3 rise in pollutant level led to statistically significant relative risks (RR) for respiratory morbidity: 1.033 for O_3, 1.004 for NO_2, 1.006 for RSPM
Nidhi *et al.*, 2007[24]	Outdoor air	The relative risks of hospitalization due to respiratory diseases were 1.07–2.82
Kumar, 2007[19]	Indoor air pollution	Indoor SPM level was also significantly effects in children higher in homes of children with a history of respiratory illness
Agarwal *et al.*, 2006[12]	Outdoor air	SPM (r = 0.474; P <0.01) and RSPM (r = 0.353; P <0.05) showed a significant positive correlation with the number of COPD cases. Winter months had higher risk
Pande *et al.*, 2002[25]	Outdoor air	Emergency room visits for asthma, COAD and acute coronary events increased by 21.30%, 24.90% and 24.30%, respectively, due to higher than acceptable levels of air pollutants

for smooth traffic flow, introduction of Metro rail and CNG for commercial transport vehicles (buses, taxis, auto rickshaws), phasing out of very old commercial vehicles, introduction of mandatory "Pollution Under Control" certificate with 3-month validity and stringent enforcement of emission norms complying with Bharat Stage II/Euro-II or higher emission norms. Introduction of The Air Ambience Fund levied from diesel sales and setting up of stringent emission norms for industries and thermal power stations are the other measures. Environmental awareness campaigns are also carried out at regular intervals. The Delhi Pollution Control Board conducts monthly Ambient Air Quality Monitoring at 40 locations in Delhi, and takes corrective action wherever necessary.

Industrial Policy

The first Industrial Policy for Delhi was introduced in 1982. Subsequently, a second Industrial policy (2010–2021) was issued by the Department of Industries, Government of Delhi. It is a comprehensive document envisioning higher industrial development in Delhi, with one of its mandates being to develop clean and non-polluting industries and details of steps to be undertaken in this direction have been described.

There are many other organizations that work synergistically with the government efforts to reduce air pollution. These include the Centre for Science and Environment and The Energy and Resources Institute, and the Indian Association for Air Pollution Control. Representatives of the industries include Confederation of Indian Industry and Society of Indian Automobile Manufacturers. Government agencies like Factories Inspectorate are also involved in the control of pollution. Research and academic institutions include National Environmental Engineering Research Institute, Indian Institute of Technology, Council of Scientific and Industrial Research institutions, Indian Agricultural Research Institute and various other academic institutions in and around Delhi. Professional organizations like the Indian National Science Academy, the Indian Institute of Chemical Engineers and the Indian Institute of Engineers are also involved in pollution control.

Benefits Accrued as a Result of Control Measures

Since the first act on pollution was instituted, huge progress has been made in terms of human resource, infrastructure development and research capability. Some studies tried to gather evidence for the effectiveness of control measures by comparing pre- and post-intervention health status. The study conducted by the Central Pollution Control Board demonstrated that spending 8-10 h in clean indoor environment can reduce health effects of exposure to chronic air pollution.[10] A recent study found significant improvement in the respiratory health following large-scale government initiatives to control air pollution.[26] It was reported that use of lower-emission motor vehicles resulted in a significant gain in disability-adjusted life-years in Delhi.[27] Another study found significant evidence for reduction in respiratory illness following introduction of control measures.[24]

Most of the studies were ecological correlation studies, which are severely limited in their ability to draw causal inferences. But, considering the context that demanded the research, these were probably the best available designs to produce preliminary and,sometimes, policy-influencing evidences, as any other methodology would be unethical or operationally impossible.

Conclusion

The Government of National Capital Territory of Delhi has taken several steps to reduce the level of air pollution in the city during the last 10 years. The benefits of air pollution control measures are showing in the readings. However, more still needs to be done to further reduce the levels of air pollution. The already existing measures need to be strengthened and magnified to a larger scale. The governmental efforts alone are not enough. Participation of the community is crucial in order to make a palpable effect in the reduction of pollution. The use of public transport needs to be promoted. The use of Metro rail can be encouraged by provision of an adequate number of feeder buses at Metro stations that ply with the desired frequency. More frequent checking of Pollution Under Control Certificates needs to be undertaken by the civic authorities to ensure that vehicles are emitting gases within permissible norms. People need to be educated to switch-off their vehicles when waiting at traffic intersections. Moreover, the "upstream" factors responsible for pollution also need to be addressed. The ever-increasing influx of migrants can be reduced by developing and creating job opportunities in the peripheral and suburban areas, and thus prevent further congestion of the already-choked capital city of Delhi.

Health, as we all know, is an all-pervasive subject, lying not only within the domains of the health department but with all those involved in human development. Many great scholars from Charaka to Hippocrates have stressed the importance of environment in the health of the individual. Therefore, all those who play a role in modifying the environment in any way, for whatever reason, need to contribute to safeguard people's health by controlling all those factors which affect it.

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