

Chapter 7

Environmental Toxicological Studies with Reference to Increasing Asthma Cases in Rural and Urban India

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Abstract Asthma is a chronic condition characterized by swelling of walls and contraction of smooth muscles in the airway with the secretion of thick, tenacious mucus resulting in narrowing/obstruction of the airways. It affects people regardless of age, and in some cases can prove to be fatal. Growing incidence of asthma in both developed and developing countries has been a major public health challenge for more than two decades. In this review, we will discuss different instances indicating the detrimental effect of environmental pollution. One of the major issues of interest will be whether the daunting levels of environmental pollution in India has a great impact on lung diseases particularly asthma and allergic diseases.

Keywords Asthma • Toxicological studies • Rural • Urban • Environmental pollution

1 Introduction

Vehicle traffic is one of the most significant emission sources of air pollutants in urban areas. Vehicle-related emissions can cause severe air pollution problems in many sectors, and air pollution associated with traffic is a widespread environmental concern (Colville et al. 2001). Exposure to traffic-generated pollutants, which include oxides of nitrogen (NO_x), carbon monoxide (CO), volatile organic carbon (VOC), and particulate matter (PM), can cause adverse health effects such as impaired lung function and asthma (Anderson et al. 2011; Clark et al. 2010), deficits in lung function growth (Gauderman et al. 2007), and cancer (Buffler et al. 2005;

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Langholz et al. 2002). Vulnerable groups include individuals with existing respiratory and cardiovascular disease, e.g., children with asthma (Gasana et al. 2012; Lindgren et al. 2010).

1.1 Global Scenario

Approximately 300 million people are asthma patients worldwide. The global prevalence of asthma is anticipated to be about 4.5%. There are about 334 million patients with asthma affecting all age groups, across the world. The prevalence of asthma has increased over time, and an additional 100 million people worldwide are expected to develop asthma by the year 2025 (Behera and Sehgal 2015).

1.2 Indian Scenario

According to the Indian Council of Medical Research (ICMR), the number of asthmatics in India is approximately 30 million. Asthma affects 3–38% of children and 2–12% of adults. There is an increasing evidence of the negative health impact resulting from environmental air pollution, in particular, that associated with respiratory diseases and allergy. The growing prevalence of respiratory diseases and allergy such as asthma has drawn attention to the potential role of air pollution in causing this (Behera and Sehgal 2015).

In the Indian Study on Epidemiology of Asthma, Respiratory Symptoms and Chronic Bronchitis in adults (INSEARCH), a survey conducted in two phases across 16 centers in India, the prevalence of asthma in adults was 2.05%, with an estimated burden of 17.23 million (Aggarwal et al. 2006). A recent analysis using three different assessment models, i.e., INSEARCH, Global Initiative for Asthma (GINA), and World Health Organization (WHO) survey suggests that the prevalence of asthma in India varies between 2.05 and 3.5% which roughly amounts to 17–30 million patients (Agarwal et al. 2014). The estimated cost of asthma treatment per year for the year 2015 has been calculated to be approximately Rs. 139.45 billion (Murthy and Sastry 2015). An estimated 15 million Disability-Adjusted Life Years (DALYs) are lost due to asthma (To et al. 2012).

Data published by the Health Effects Institute indicates that a $10 \mu\text{g m}^{-3}$ increase in PM_{10} , the coarse particulate fraction of air pollution, is associated with an increase in mortality of 0.6% in daily all natural cause mortality in the main cities such as India and China (HEI, International Scientific Committee 2010).

Recently, a nationwide survey called “*Breath Blue 15*” concluded that the lung health of children in metropolitan cities of India is poor. In all, 2000 children in the age group of 8–14 years were screened for lung health status. Out of children population in Delhi, 40% were found to have ratings of “*bad*” to “*poor*” lung health, while Bengaluru followed closely with 36%, Kolkata with 35%, and Mumbai with 27%.

It is no coincidence that these cities are some of the most polluted cities in the world. Air pollution levels in these cities are at an all-time high, owing to multiple factors such as overcrowding, mass immigration, the rise in vehicular population and consequent smoke emission, and industrial activity.

1.3 Prevalence of Asthma: Urban vs. Rural Areas

It has been suggested that, compared to urban dwellers, people living in the countryside generally have better health, along with fewer disabilities and long-term limiting illnesses (Iversen et al. 2005). Coherent evidence shows that differences in the prevalence of asthma morbidity between urban and rural areas exist (Yemaneberhan et al. 1997; Ellison-Loschmann et al. 2004; Smith et al. 2009). Such difference in the prevalence of asthma morbidity may result from increasing urbanization, or from socioeconomic and cultural factors, as well as individual societal factors.

Vehicular pollution, particularly in metropolitan cities experience thick smog and haze resulting in asthmatic attacks. When combined with smog and other atmospheric pollutants, illness from allergic respiratory diseases, particularly asthma, could increase.

The quality of air is likely to decrease as surface ozone concentrations begin to rise with increasing temperatures. This will lead to an increasing incidence of asthma and other cardiovascular and respiratory diseases (Liggins 2008). This issue is being addressed by the Govt. of India by introducing compressed natural gas (CNG) for transport and replacement of wood fire for cooking by the liquid petroleum gas (LPG) in villages (USAID/ASIA Report 2007). It is an excellent example of co-benefits of other sectors to human health.

Indian cities today are among the most polluted areas in the world, and it is estimated that outdoor air pollution leads to approximately 670,000 deaths annually (Lim et al. 2013). Current standards, for particulate matter set by the Central Pollution Control Board (CPCB 2009), are much higher than those recommended by the WHO (Krzyzanowski and Cohen 2008). Also, unlike other countries (Bell et al. 2003; Dominici et al. 2007), the CPCB does not take into account findings from health literature when deciding on air quality standards (Balakrishnan et al. 2011).

A periodic review of epidemiological evidence informs policy makers about current health risks associated with air pollution and sets the agenda towards finding a balance between reducing health impacts and the costs of implementing further air pollution controls (Dominici et al. 2004). An interesting finding of the analysis is that cities such as Ahmedabad and Mumbai that have higher levels of pollution experience a relatively lower increase in mortality for every 10 mg m^{-3} increase in PM_{10} . In contrast, the percentage increase in mortality is highest for Shimla which is among the cleanest cities. The percentage increase in mortality associated with a 10 mg m^{-3} increase in PM_{10} is highest for Shimla (1.36%) and the least for Ahmedabad (0.16%). Bangalore and Mumbai showed similar results with a 0.22%

and 0.20% mortality increase, respectively, at a 95% confidence interval. Findings suggested that small reductions in pollution in cleaner cities will yield tremendous health benefits, whereas, in less clean cities, even significant reduction in pollution may yield only modest health advantages in a relative sense.

Indian metropolitan cities remain exposed to high levels of air pollutants mainly due to high vehicular movements and poor roads. Although the concentration of these pollutants varies according to the traffic density, type of vehicles, and time of day, some people by their occupation are more exposed to high levels of traffic-related air pollutants. These people include filling station workers, traffic police officers, professional drivers, and toll booth workers because of the proximity and high emissions from vehicle idling, deceleration, and acceleration (Sehgal et al. 2014).

In a recently conducted study on air quality monitoring (PM_{2.5}, CO, NO_x, SO₂, and EC/OC) at highway toll plazas, municipality toll plazas, and control sites which were 23 in number, it was found that there was a high level of air pollution at almost all locations with PM_{2.5} values exceeding the national permissible limit (60 µg m⁻³) except at a few control sites. The study found that pollutant concentrations were highest at municipality toll plazas with minimum protective work areas. The observed reduction in lung function indices was significant over years of occupational exposure even after making adjustments for age, among non-smoking outdoor workers (TERI 2015).

Some studies have suggested that ambient air pollution can trigger asthma attacks (Bjorksten 1999; Koren and Utell 1997). Exposure to several specific air pollutants, such as respirable particulate matter (RSPM) [≤ 10 µm in aerodynamic diameter (PM₁₀)], carbon monoxide (CO), ozone (O₃), sulfur dioxide (SO₂), and nitrogen dioxide (NO₂), has been associated with increased asthma symptoms (Baldi et al. 1999; Bates 1995; Castellsague et al. 1995; de Diego Damia et al. 1999; Greer et al. 1993; Hajat et al. 1999; Koren 1995; Zhang et al. 1999).

2 Case Studies

India has about 10% of the global asthma burden of between 100 and 150 million people—roughly the equivalent of the population of Russia. This number is increasing, and global deaths due to asthma have reached over 1,80,000 annually (Times of India Report 2015).

The primary source of suspended particulate in Delhi is burning of fossil fuels, power stations, vehicular transport, industries, domestic coal, and open biomass burning. Vehicle exhausts have been implicated for an increased prevalence of wheeze, rhinitis, asthma, and other respiratory symptoms in children (Ciccone et al. 1998). Few studies (Shima et al. 2002; Edward et al. 1994) have reported air pollution as a causative factor for asthma. In a 6-year follow-up study (Shima et al. 2002) among Japanese children, a significant association was found between the annual average concentration of NO₂ and the incidence of asthma.

Many northern cities including Agra, Patna, and Lucknow continue to show an alarmingly high pollution level. The pollution levels in few Indian cities have earned the embarrassing distinction of having exceeded the toxic levels of Beijing and other Chinese cities, demonstrating levels at least ten times higher than the WHO standards, making air pollution indeed a national emergency.

Greenpeace India analyzed the data provided by the National Air Quality Index (NAQI) portal and concluded that control strategies need to move beyond just Delhi because air pollution seems to be a regional problem rather than just local one. The organization said that steps are needed at national level to reduce the levels of particulate matter PM_{2.5} and PM₁₀ (Myllyvirta and Dahiya 2015).

While Delhi was found to have pollution levels 12 times higher than WHO guidelines, another six cities—Lucknow, Faridabad, Ahmedabad, Kanpur, Agra, and Varanasi—had pollution levels at least ten times as higher than permissible under these standards.

Greenpeace also compared the levels of pollution in Indian cities to Beijing's red-alert standard and estimated how many days the cities would be shut if they were following China's rules of issuing alerts in times of severe air pollution. It turned out that in a 91-day period between September and November, Delhi met the Chinese criteria for 33 days while Lucknow met it for 40 days.

In 2014, the WHO released a list of world's 20 most polluted cities, 13 of which were in India (WHO Report 2014). Earlier, the Global Burden of Disease (GBD) report had estimated air pollution to be the fifth deadliest killer in the country (GBD Report 2013).

Even as Indian cities remain exposed to critically high levels of toxic substances in their air, the absence of comprehensive data collection makes things worse. Delhi is now the 11th most polluted city in the world, based on average annual PM_{2.5} readings of 3000 cities in 100 countries while Gwalior (2), Allahabad (3), Patna (6), and Raipur (7) figured in the top seven (WHO 2016).

Cases of severe breathlessness, asthma and allergy have sharply risen in Delhi as the city was recently blanketed in a thick layer of toxic air due to the worst smog in 17 years. A thick shroud of menacing gray haze enveloped the national capital even as pollution level breached the safe limit by over 17 times at many places (The Indian Express Report 2016).

Air pollution is one of the top 10 killers in the world and the fifth leading cause of death in India said the study titled *Body Burden 2015: State of India's Health* (Narain et al. 2015). In 2015, the highly polluted conditions in the capital saw a spurt in asthma cases by up to 20% when compared to the previous year. After Diwali, the number of asthmatic patients has increased substantially. The Delhi High Court has observed that living in Delhi is like living “*in an open gas chamber.*”

To curb this menace, the Delhi Government initiated an odd-even plan which restricted the movement of vehicles to a great extent thus resulting in a decline in air pollution levels to a certain degree. Also, given managing pollution concentrations in the city, the Supreme Court has decided to double the “*green tax*” on commercial vehicles entering the city in a bid to curb air pollution in the national capital by discouraging such vehicles from using city roads to avoid tolls on other routes. For

taxi services like Ola and Uber, the court is likely to direct a complete shift to CNG from diesel. It is also liable to order the civic bodies in Delhi and the central government to ensure that no waste shall be burned in the city. Further, the court may stop vehicles older than 2005 from entering the city limits. According to a study released by environment research organization Centre for Science and Environment, air pollution claims at least 10,000 to 30,000 lives a year in Delhi (Livemint 2015).

The odd-even pilot reduced hourly particulate air pollution concentrations by 10–13%. This car ban may help cut emissions of the smallest particles because combustion of fuel in vehicles produces these directly. But for the longer run, a congestion-pricing program may be better.

Air pollution is shortening lives in Delhi and too many other places in India and elsewhere. The odd-even scheme has delivered over these 2 weeks, but may not over the long term. Furthermore, vehicles are only one source of pollution.

There is no shortage of creative ideas and potential pilots, but what is all too often lacking is evidence on which ones work as intended. In one effort to improve matters, the University of Chicago has launched a competition with the Delhi Dialogue Commission to crowdsource ideas for reducing air and water pollution (the Delhi Urban Labs Innovation Challenge). More generally speaking, governments need to accept that we don't have all the answers to policy problems and adopt a culture of trying out new ideas, testing them carefully, and then deciding which ones to choose at scale.

The Delhi government's odd-even road rationing policy resumed with the government evaluating the effects of the implementation between January 1 and January 15, 2016. The second phase of the odd-even plan was also implemented from April 15 to 30, 2016. Delhi Pollution Control Committee (DPCC) data shows peak levels of O_3 dropped this year at some stations in Central Delhi. According to scientists, the real impact of the scheme could be accessed scientifically only after comparing the 15 days with the whole summer season as was done for the January data. The data of the odd-even fortnight needs to be compared with the entire winter season to understand its impact on air quality.

The agenda behind the policy is necessary to comprehend. The aim of the implementation was to arrest the peaks of pollution as was done in winter. Even if the ambient air quality does not indicate that it needs to be understood that the actual human exposure has come down significantly. The study shows broadly consistent impact on traffic congestion over two rounds of odd-even in Delhi suggesting that it can be a short-term or emergency measure in the future too. Odd-even led to a consistent reduction in traffic congestion, which was remarkably stable across the two rounds (The Indian Express Report 2016).

Beyond odd-even, an IIT Kanpur report titled "*Source Apportionment Study of $PM_{2.5}$ and PM_{10}* " on air pollution in Delhi has made a slew of recommendations required till 2023 after identifying the top sources of emission.

Along with vehicles, construction, and industries, the study has identified road dust, coal-based tandoors, and concrete batching as primary sources of air pollution in Delhi. The study has estimated the total PM_{10} emission load in the city at 143 tons

day⁻¹ and listed the top contributor as road dust (56%) and the PM_{2.5} load at 59 tons day⁻¹, the top contributors being road dust (38%) and vehicles (20%), followed by domestic fuel burning and industrial point sources.

2.1 Vehicles

These are the second largest source of particulate matter, particularly PM_{2.5}. According to the report, vehicular pollution grew from 64 to 72% between 1990 and 2000. In winter, on average vehicles can contribute 25% to PM_{2.5} and at certain locations this could be above 35%. There is a significant contribution of diesel vehicles to PM₁₀ and PM_{2.5}.

2.2 Road Dust

The silt load on some of Delhi's roads is very high, and silt can become airborne with the movement of vehicles. The estimated PM₁₀ emission from road dust is over 65 tons day⁻¹. Soil from open fields too gets airborne in summer. In some parts of the city, roads are broken, poorly maintained and partially paved surfaces and the study found that movement of vehicles may cause non-exhaust road dust emission in significant amounts. PM₁₀ and PM_{2.5} emission from road dust is 79,626 and 22,165 kg day⁻¹, respectively.

2.3 Concrete Batching

During the study period, massive construction activities were found that required concrete batching, including at 60 Delhi Metro Rail Corporation (DMRC) locations where construction was under progress. It was assumed that there would be 40 concrete batching plants of 120 cu.m h⁻¹ capacities operating for 16 h. Several medium and small construction activities were also observed in the city. PM₁₀ and PM_{2.5} emissions from concrete mix plants are estimated at 14.37 and 3.5 tons day⁻¹, respectively. A few hundred plants in National Capital Region (NCR) may contribute to this.

2.4 Hotels and Restaurants

Details of hotels and restaurants were obtained from DPCC and related websites. The field survey found that hotels, restaurants, etc. use coal as fuel in tandoors. The average consumption of fuel in tandoors based on the study was 30 kg day⁻¹. The number of hotels and restaurants was 36,099 (Delhi Statistical Handbook 2014). The study assumes 25% of these enterprises use tandoors for food preparation.

2.5 *Municipal Solid Waste Burning*

The contribution of burning MSW is surprising. A study in Delhi has estimated 190–246 tons day⁻¹ of MSW burning (Nagpure et al. 2015). This emission, it says, is expected to be large in the regions of economically lower strata of the society, which do not have the infrastructure for collection and disposal of MSW.

2.6 *Diesel Generator Sets*

Diesel generator sets are used as the source of power in shopping complexes and industries during the power-cut hours. The IIT Kanpur survey concluded that there is a minimum of 2 h day⁻¹ power cuts in the city, especially in summer.

The study highlights the importance of involving the NCR cities in controlling air pollution. According to the report, sources outside Delhi (excluding secondary particles) contribute about 100 $\mu\text{g cu.m}^{-1}$ of PM₁₀ and 59 $\mu\text{g cu.m}^{-1}$ of PM_{2.5} in Delhi.

The problem of air pollution is not only restricted to the plains, but the hilly states have also been affected by it during the recent years. Similar steps have also been taken by National Green Tribunal (NGT) to combat air pollution levels in Himachal Pradesh capital Shimla. The NGT has directed the state Government to impose Rs. 500/- as “*green tax*” on each vehicle emitting pollution on Shimla’s restricted roads, including the Mall Road.

Also in a bid to curb pollution levels across Himachal Pradesh, electric buses would now be used as the public mode of transport across all the routes. The distance between Manali and Rohtang Pass would be covered by CNG buses. Efforts to introduce an alternate mode of transportation are on after NGT took cognizance of diesel and petrol vehicles that are being used more and more nowadays with the increasing tourist influx. The decision would discourage the usage of diesel vehicles and would encourage the use of eco-friendly vehicles.

3 Discussion

There is now adequate affirmation to reveal that the practical damaging effect of contaminated environment on asthma and allergic diseases primarily observed in the developed countries is now occurring in developing countries like India. The evidence also supports the finding that outdoor air pollution poses significant adverse effects on allergic diseases and respiratory health, while its risk level may be modified by the temporospatial and meteorological changes. Children and the elderly are particularly vulnerable to the effects of air pollution (Zhang et al. 2015).

While further extensive and more comprehensive studies are needed, the currently available data would serve as an important evidence-based foundation in establishing the link between the outdoor air pollution and allergic diseases. The health implications and the importance of regional and intra-city differences and the combination of pollutant constituents should continue to be investigated. While the epidemiological evidence alone still carries some degrees of uncertainty in defining the environmental etiology, accumulated experimental evidence has provided evidence supporting their causative role. The solution to this problem is of course to reduce emissions of these pollutants. On the other hand, effective preventive measures and treatments need to be found.

A lot has to be done to reduce the burden of asthma in India. Cities have to be decongested, and rapid urbanization has to be checked. Vehicular emissions have to be measured, and erring vehicles should be kept off the roads. Deforestation and cutting of trees in urban areas have to be reduced; every area in a city should have a green space. Smoking has to be reduced through legislation and public health messages.

More than law and policy making, people should be disciplined enough to make sure that they are not contributing to air pollution themselves. Switching off engines of vehicles at traffic junctions, using public transport, and car-pooling may be simple, but effective ways of contributing to the environmental cause. It is important to remember that by causing air pollution, we are affecting the health and future of our children.

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