Review of Air Pollution and Health Impacts in India

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ABSTRACT

Exposure to air pollution is an inescapable part of our urban life. The health risks due to air pollutants are quantified by estimating the relationship between air quality and health effect.

In this paper, we present an overview of the emission sources and better air quality in Indian cities, with a particular focus on interventions like urban public transportation facilities and waste management to control open waste burning. Several air quality standards and guidelines have been introduced by the Central Pollution Control Board (CPCB) of the Indian Ministry of Environment and Forests to reference and regulate urban air quality. Under the National Ambient Air Quality Monitoring (NAAQM) network, three criteria air pollutants, namely, PM, SO_2, and NO_2 have been identified for regular monitoring at all the 290 stations spread across the country. Particulate matter is one of the most critical air pollutants in most of the urban areas in the country and permissible standards are frequently violated several monitored locations. In India, millions of people breathe air with high concentrations of dreaded pollutants. The air is highly polluted in terms of suspended particulate matter in most cities. Many strategies, such as recycling, changes in engineering control equipment, and air cleaning systems, have been applied to improve air quality.

Key words: Air pollution, Sources of air pollution, Air quality, ambient air quality guideline, Health Impact

INTRODUCTION

Air pollution problems have been multiplying steadily in India with the growth of population and industry. Many of these problems are typically urban character as they are related to the activities of the general population in the consumption of fuels for heating, power and transportation and specific emissions of pollutants from industry concentrated in the urban environment.

Air is never perfectly clean. Many natural sources of air pollution have always existed. Ash from volcanic eruptions, salt particles from breaking waves, pollen and spores released by plants, smokes from forest and brushfires, and windblown dust are all examples of natural air pollution. Human activities, particularly since the industrial revolution, have added to the frequency and intensity of some of these natural pollutants.

Today air pollution is the major issue that has been affecting human health, agriculture crops, forest species and ecosystem. Monitoring data and studies on ambient air quality show that some of the air pollutants in several large cities are increasing with time and are not always at acceptable levels according to the national ambient air quality standards.

This paper reviews the results of ambient air quality monitoring and studies related to air pollution in India and its impact on human health.

DISCUSSION

Sources of air pollution

The major sources of air pollution in India are mobile sources, stationary sources, and open burning sources. Since last five years, emissions from mobile sources (i.e., motor vehicles) have been the major source of air pollution, contributing to at least 60–70% of the total air pollution. Emissions from stationary sources generally have contributed to 30–35% of the air pollution, while open burning and forest fires have contributed approximately 5–7%. According to the Environment Protect Agency (EPA, 2003).

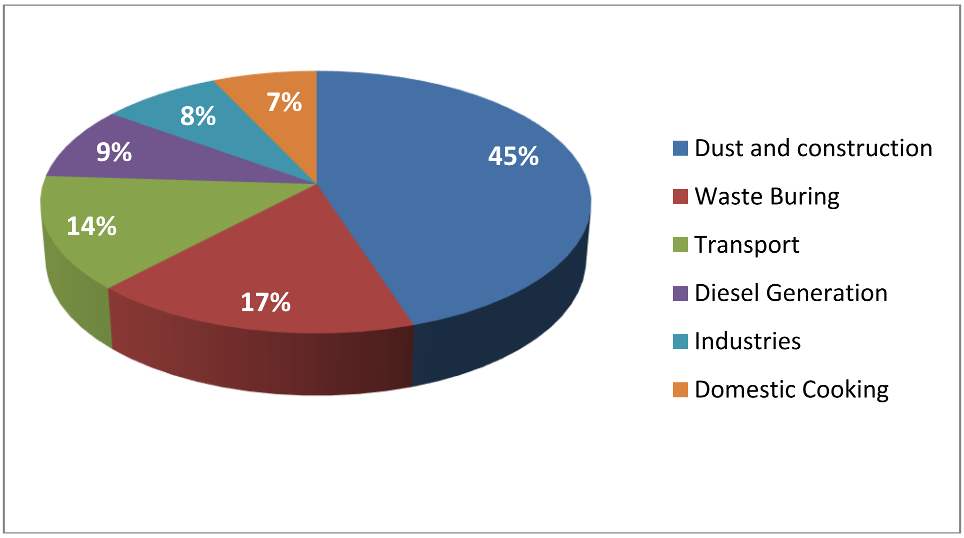

Fig. 1. Sources of Air Pollution in India, 2019.
Source: Environmental Protection Agency, 2003 & CPCB.

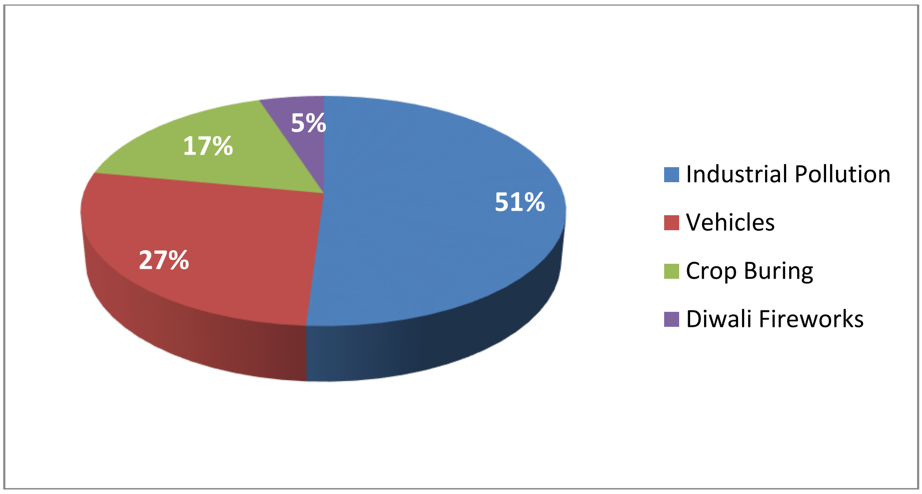

Fig. 2. Sources of Air Pollution in India, 2016.
Source: Environmental Protection Agency, 2003 & CPCB.

Air pollution in India is a serious health issue. Of the most polluted cities in the world, 21 out of 30 were in India in 2019 **(Fig.1).** As per a study based on 2016 data, at least 140 million people in India breathe air that is 10 times or more over the WHO safe limit and 13 of the world's 20 cities with the highest annual levels of air pollution are in India. The 51% of pollution is caused by the industrial pollution, 27% by vehicles, 17% by crop burning and 5% by Diwali fireworks **(Fig. 2).** Air pollution contributes to the premature deaths of 2 million Indians every year. Emissions come from vehicles and industry, whereas in rural areas, much of the pollution stems from biomass burning for cooking and keeping warm. In autumn and winter months, large scale crop residue burning in agriculture fields – a cheaper alternative to mechanical tilling – is a major source of smoke, smog and particulate pollution. India has a low per capita emission of greenhouse gases but the country as a whole is the third largest greenhouse gas producer after China and the United States. A 2013 study on non-smokers has found that have 30% weaker lung function than Europeans.

The Air (Prevention and Control of Pollution) Act was passed in 1981 to regulate air pollution but has failed to reduce pollution because of poor enforcement of the rules.

In 2015, Government of India, together with IIT Kanpur launched the National Air Quality Index. In 2019, India launched 'The National Clean Air Programme' with tentative national target of 20%-30% reduction in PM2.5 and PM10 concentrations by 2024, considering 2017 as the base year for comparison. It will be rolled out in 102 cities that are considered to have air quality worse than the National Ambient Air Quality Standards. There are other initiatives such as a 1,600-kilometre-long and 5-kilometre-wide The Great Green Wall of Aravalli green ecological corridor along Aravalli range from Gujarat to Delhi which will also connect to Shivalik hill range with planting of 1.35 billion (135 crore) new native trees over 10 years to combat the pollution.[6] In December 2019, IIT Bombay, in partnership with the McKelvey School of Engineering of Washington University in St. Louis, launched the Aerosol and Air Quality Research Facility to study air pollution in India.

Mobile sources include motor vehicles such as personal cars, commercial vehicles, and motorcycles. By the end of 2017, there were 2.53 lacks vehicles registered in India, compared to 1.42 lacks in 2012, an increase of almost 1.2 lacks vehicles (*Source* Ministry of Road Transport and Highways). These conditions have caused severe congestion in almost all parts of the highway network and corridors, especially in the central business areas, and inevitably the environment in these areas has deteriorated due to exhaust emissions from motor vehicles.

Two recent accomplishments will reduce the negative impact of mobile sources on air quality: the approval of new environmental regulation amendments the Environmental Quality Act (EQA), and the phase-out of leaded gasoline sales. A significant first step toward implementing Clean Air Plan was achieved in 1996 with the approval of two regulations designed to reduce emissions from mobile sources: The Environmental Quality (Control of Emissions from Diesel Engines) Regulations 1996 and the Environmental Quality (Control of Emissions from Petrol Engines) Regulations 1996. The new regulations focus on prevention by controlling vehicular emissions at the manufacturing or assembly stage. The emissions standards in the new regulations are based on the European Economic Commission on Standards.

Stationary sources are related to industry, power stations, industrial fuel burning processes, and domestic fuel burning. Most of the stationary sources in India reside in Delhi, Mumbai, Kolkata, Hyderabad, Chennai and Pune etc. Increased activity from the industrial sector has been accompanied by an increased use of energy and commodities traffic. Most of the small and mid-sized industries do not install pollution control equipment. This increases the emission of pollutants, especially in the industrial areas, which in some cases contributes specific pollutants to the air. Moreover, small industries are generally located in populated areas where emission control is more problematic. To overcome the problem, the EQA lists the following standards for stack gas emissions **(Table 1).**

Table No.1: Stack Gas Emission Standards

Emission Sources	Standards
Dark Smoke	
Solid fuel equipment	Ringlemann Chart No. 2
Other fuel types	Ringlemann Chart No. 1
Dust	0.1 – 0.4 gm/Nm^3 (source dependent)
	0.01 gm/Nm^3
Metal and metallic compounds	
Mercury	0.015 gm/Nm^3
Cadmium	0.025 gm/Nm^3
Lead	0.025 gm/Nm^3
Antimony	0.025 gm/Nm^3
Arsenic	0.1 gm/Nm^3
Zinc	0.1 gm/Nm^3
Gases	
Acid gases	3.5g of SO_3/Nm^3
Sulphuric acid mist, SO_3	0.2g of SO_3/Nm^3
Chlorine gas	0.2g of Hcl/ Nm^3
HCl	0.4g of Hcl/ Nm^3
Florine	0.3 hydrofluoric acid g/ Nm^3
Hydrogen sulphide	5 ppm (vol %)
NO_x	1.7 – 2.0 of SO_3/Nm^3 (source dependent)

Source: EPA, 2003, MoEF & CPCB

Open burning sources of air pollution in India include the burning of solid wastes and forest fires. This is common at some poorly managed disposal sites and results in smoke and fly ash problems. Over the last several years significant amounts of particle matter have been transported due to uncontrolled biomass burning activities. Haze conditions are aggravated by local emissions from motor vehicles, industries, and open burning activities. At its worst, the haze limits visibility to less than 500m and produces respirable particles of concentrations up to 500g/m^3 (Afroz 2003).

Air Quality in India

India has experienced substantial increases in vehicle miles traveled (VMT) in recent years. The increased traffic has resulted in increased pollutant emissions and the deterioration of environmental quality and human health in several major cities in India. Aurangabad, the capital city of Marathawada region the State of Maharashtra, is among the rapidly-growing. Indian cities facing serious air quality problems due to vehicular air pollution. Specifically, pollutant concentrations near major intersections and roadways in the city are exceeding the Indian National Ambient Air Quality Standards (NAAQS). Thus, users (motorists, pedestrians, residents, etc.) in these corridors are exposed to unhealthy pollution levels (Nagendra et al., 2004). Exposure to vehicular air pollution directly affects respiratory, nervous and cardiovascular systems of humans, resulting in impaired pulmonary functions, sickness, and even death (Hall, 1996).

Several air quality standards and guidelines have been introduced by the Central Pollution Control Board (CPCB) of the Indian Ministry of Environment and Forests to reference and regulate urban air quality. Of particular importance are the Air (prevention and control of pollution) Act (1981), the Environmental Protection Act (1986), the Motor Vehicles Act (1988) and the Central Motor Vehicles Rules (1989). The Indian NAAQS for criteria pollutants are summarized in **Table 2.** These standards and guidelines address individual pollutants and are developed based on highest percentile values over various averaging periods (Central Pollution Control Board, 2000). As such, it is difficult to incorporate these standards into a reference scale. Further, the awareness of high air pollution concentrations and or even the frequency of with which the NAAQS are exceeded is not sufficient for the citizens to assess urban air quality. The general public needs information on the levels and potential health risks of air pollution presented in a simple, understandable format. In recent years, air quality indices (AQIs) as suggested by the US Environmental Protection Agency (EPA) are used in many cities to highlight the severity of air pollution and risks of adverse health effects (Environmental Protection Agency, 2003). The AQIs are related to the overall status of air pollution via a pre-defined set of clearly identified criteria. These criteria should be universal and irrespective of the level of pollution. It should be sufficiently flexible to account for different levels of population exposure, variable meteorological and climatic conditions occurring in an area as well as the sensitivity of flora and fauna (Environmental Protection Agency, 1998). Longurst (2005) illuminated the complexity of adequately conveying pollution exposure and health effects information to the public via an AQI (Nagendra et al., 2007).

Table No.2: Indian national ambient air quality standards and WHO guidelines for air quality

Pollutant	Time-weighted average	Concentration of pollutants in ambient air		
		India	USA	WHO
PM_{10}	Annual[a] 24-hour[b]	60 100	-- 150	20 50
$PM_{2.5}$	Annual[a] 24-hour[b]	40 60	15 35	10 25
SO_2	Annual[a] 24-hour[b] 1 - hour	50 80 --	-- -- 75 (ppb)	-- 20 --
NO_2	Annual[a] 24-hour[b] 1 - hour	40 80 --	53 (ppb) -- 100 (ppb)	40 -- 200
CO	24-hour[b] 8 - hour 1 - hour	-- 2000 4000	-- 9 (ppb) 35 (ppb)	-- -- 30,000
Ozone	8 - hour 1 - hour	100 180	0.075 (ppm) --	100 --
All the values are in µg/m3, except for those with units listed in brackets				

Source: MoEF & CPCB, 2000c.
However, 2% of the time, it may exceed but not on two consecutive days.
a Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.
b 24 hourly/8 hourly values should be met 98% of the time in a year.

Air quality indices

In 1976 the EPA established a uniform AQI, also called the pollutant standard index (PSI), for the use of state and local agencies to assess urban air quality on a voluntary basis. The AQI includes sub-indices for ozone (O_3), PM, carbon monoxide (CO), SO_2, and nitrogen dioxide (NO_2), which relate ambient pollutant concentrations to index values on a scale from 0 to 500. The index is normalized across pollutants by assigning an index value of 100 to the primary NAAQS for each pollutant and an index value of 500 as the pollutant level associated with risks of significant harm (Environmental Protection Agency, 1994). The EPA made major changes in 1999 to its previous AQI. The changes resulted in index values ranging from 0 to 500 being divided into six groups to characterize the relationship between daily air quality and associated public health effects. **Table 3** shows the AQI ranges, corresponding health effects and associated colour codes suggested by the Environmental Protection Agency (2003).

Table No.3: The Indian Air Pollution Index

Index Values	Descriptor	Colour codes
0 – 50	Good	Green
51 – 100	Moderate	Yellow
101 – 150	Unhealthy for sensitive group	Orange
151 – 200	Unhealthy	Red
201 – 300	Very unhealthy	Purple
301 – 500	Hazardous	Maroon

Source: environmental Protection Agency, 2003.

Ambient Air quality Monitoring

The ambient air quality at various locations, a monitoring network has been established comprising of 295 stations covering 98 cities/towns in 29 States and three Union Territories under the Air (Prevention and Control of Pollution) Act, 1981, as amended in 1988. Under this programme, four criteria air pollutants viz. Sulphur dioxide (SO_2), oxides of nitrogen (NOx), Suspended Particulate Matter (SPM) and Desirable Suspended Particulate Matter (RSPM) are regularly monitored at all the locations. Besides this, additional parameters such as desirable lead and other toxic trace matters and polycyclic aromatic hydrocarbons are also being monitored in 10 metro cities of the country. The ambient air quality is monitored by Central Pollution Control Board (CPCB) in coordination with the State Pollution Control Boards, Pollution Control Committees and some of the universities and research institutes.

Under the National Ambient Air Quality Monitoring (NAAQM) network, three criteria air pollutants, namely, PM, SO_2, and NO_2 have been identified for regular monitoring at

all the 290 stations spread across the country. CPCB (2000c) analyses the status and trends of air quality at various cities in India for the period 1990-98. Annual averages of PM, SO_2, and NO_2 in 16 cities in the country between 1990 and 1998, the most prevalent form of air pollution appears to be SPM although there are many stations at which SO_2 and NO_2 levels exceed permissible limits.

Particulate matter is one of the most critical air pollutants in most of the urban areas in the country and permissible standards are frequently violated several monitored locations. Its levels have been consistently high in various cities over the past several years. The annual average minimum and maximum PM concentration in residential areas of various cities ranged from 60 $\mu g/m^3$ (at Bangalore during 1991) to 521 μg/m^3 (at Patna during 1995), while in industrial areas the annual average ranged between 53 μg/m^3 (Chennai during, 1992) and 640 μg/m^3 (Calcutta during, 1993). The mean of average values of SPM for nine years (1990 to 1998) ranged between 99 μg/m^3 and 390 μg/m^3 in residential areas and between 123 μg/m^3 and 457 μg/m^3 in industrial areas indicating that the annual average limit of suspended particulate matter for residential areas (140 μg/m^3) and for industrial areas (360 μg/m^3) had been frequently violated in most cities. The maximum suspended particulate matter (SPM) values were observed in Kanpur, Calcutta, and Delhi, while low values have been recorded in the south Indian cities of Chennai, Bangalore, and Hyderabad (Nithya 2017).

Air Pollution and Health Impacts.

There are possible short-term and long-term health effects of exposure to air pollution. In the short term, high levels of air pollution lead to an acute condition. There are a very limited number of studies that relate air pollution to its health impact in Malaysia. The lack of data gathering for environmental epidemiological analysis makes it difficult to estimate the health impact of air pollution.

In India, millions of people breathe air with high concentrations of dreaded pollutants. The air is highly polluted in terms of suspended particulate matter in most cities. This has led to a greater incidence of associated health effects on the population manifested in the form of sub-clinical effects, impaired pulmonary functions, and use of medication, reduced physical performance, frequent medical consultations and hospital admissions with complicated morbidity and even death in the exposed population. As per a World Bank (1993) study, respiratory infections contribute to 10.9% of the total burden of diseases, which may be both due to presence of communicable diseases as well as high air pollution levels, while cerebra vascular disease (2.1%) ischemic heart disease (2.8%) and pulmonary obstructions (0.6%) are much lower. The prevalence of cancer is about 4.1% amongst all the diseases indicating that the effects of air pollution are visualized on the urban population (CPCB, 2000c). A WHO /UNEP study compared standardized prevalence of respiratory diseases in different areas of Mumbai, classified according to ambient average concentrations of sulphur dioxide. The study revealed a relatively higher prevalence of most respiratory diseases in polluted urban areas than in the rural control area (WHO/UNEP, 1992, cited in Repetto, 1994). In India, in a study of 2031 children and adults in five mega cities, of the 1852 children tested, 51.4% had blood lead levels above 10μg/dl. The percentage of children having 10µg/dl or higher blood lead levels ranged from 39.9% in Bangalore to 61.8% in Mumbai.

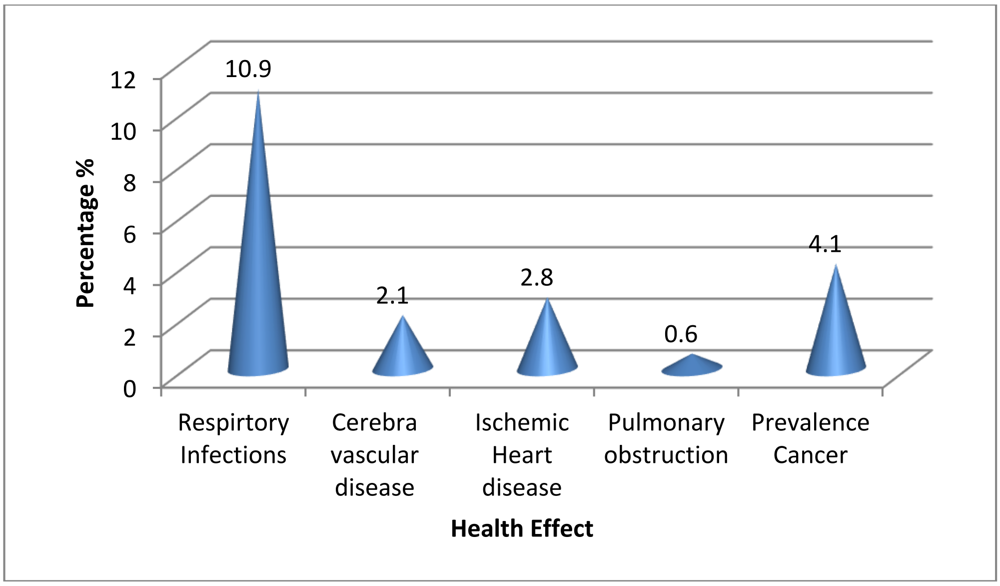

Fig. 3 : Percentage distribution of health damage costs. (Source: CPCB, 2000c & Nithya et al. 2017)

CONCLUSION

Studies related to air pollution conducted in India have been few. It is already 20 years since the Environmental Air Quality (Clean Air) Regulations 1978 were introduced in the country. Many strategies, such as recycling, changes in engineering control equipment, and air cleaning systems, have been applied to improve air quality. Many studies can be conducted to evaluate the strengths, weaknesses, the impacts of the country's adopted, regulations, programs, and strategies.

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