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Air quality review of Delhi

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Abstract
Mitigating the impact of pollution on human health worldwide is important to limit the morbidity and mortality arising from exposure to its effect. The level and type of pollutants vary in different urban and rural settings. Here, we explored the extent of air pollution and its impacts on human health in the megacity of Delhi (India) through a review of the published literature. The study aims at describing the extent of air pollution in Delhi, the magnitude of health problems due to air pollution and the risk relationship between air pollution and associated health effects. We found 234 published articles in the PubMed search. The search showed that the extent of air pollution in Delhi has been described by various researchers from about 1986 onwards. We synthesized the findings and discuss them at length with respect to reported values, their possible interpretations and any limitations of the methodology. The chemical composition of ambient air pollution is also discussed. Further, we discuss the magnitude of health problem with respect to chronic obstructive pulmonary diseases (COPD), bronchial asthma and other illnesses. The results of the literature search showed that data has been collected in last 28 years on ambient air quality in Delhi, though it lacks a scientific continuity, consistency of locations and variations in parameters chosen for reporting. As a result, it is difficult to construct a spatiotemporal picture of the air pollution status in Delhi over time. The number of sites from where data have been collected varied widely across studies and methods used for data collection is also non-uniform. Even the parameters studied are varied, as some studies focused on particulate matter ≤10 µm in aerodynamic diameter (PM10) and those ≤2.5 µm in aerodynamic diameter (PM2.5), and others on suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM). Similarly, the locations of data collection have varied widely. Some of the sites were at busy traffic intersections, some on the terraces of offices and residential houses and others in university campuses or airports. As a result, the key question of the extent of pollution and its distribution across various parts of the city could be inferred. None of the studies or a combination of them could present a complete picture of the burden of diseases like COPD, bronchial asthma and other allergic conditions attributable to pollution in Delhi. Neither could it be established what fraction of the burden of the above diseases is attributable to ambient air pollution, given that other factors like tobacco smoke and indoor air pollution are also contributors to the causation of such diseases. In our discussion, we highlight the knowledge gaps and in the conclusion, we suggested what research can be undertaken to fill the these research gaps.

Keywords: air pollution in Delhi, health problems, stubble burning, crop residue

Introduction

There is a certain percentage of gases present in the atmosphere. An increase or decrease in the composition of these gases is harmful to survival. This imbalance in the gaseous composition has resulted in an increase in earth's temperature, which is known as global warming. And in this global warming, a Union Territory that is home to India's capital, New Delhi, is among the world's urban agglomerations with the most toxic air. The magnitude of air pollution is massive. It causes devastating impacts on people's health, the city's environment, and economic well-being.

As the capital city of India, Delhi is subject to a high level of pollution year-round. The levels of fine and coarse particulate matter, known respectively as PM2.5 and PM10 are often prevalent in the air, as well as other forms of pollutants and toxic chemicals finding their way into the atmosphere, each with their own detrimental effects on human health. There are an estimated 30.2 million people registered living in Delhi as of 2020, all squeezed into a relatively small area of 1,484km², giving it an extremely high population density.

In 2019 it ranked in with a PM2.5 reading of 98.6 µg/m³, putting it in the 'unhealthy' bracket of the US Air Quality Index, which requires a PM2.5 reading anywhere between 55.5 to 150.4 µg/m³. For a city to be in the unhealthy bracket as a year-round average, it is an indicator that there are significant health hazards from the air quality. Pollution levels on the ground must be extremely high to maintain such an average, and it is well known that Delhi struggles with its population growth, with many 'urban diseases' becoming more and more apparent as the city struggles to keep up with the ever-expanding population. This would put the city under immense pressure to improve its both its residential and commercial infrastructure. As such, a result of this would be an increase in nearly all industries and a related increase in pollution directly correlating with the industrial and economic growth. Furthermore, Delhi managed to take 5th place out of every city worldwide. This placing, along with its 2019 rating falling into the unhealthy bracket, as well as three months out of the year going up a notch into the 'very unhealthy' bracket would

indicate that Delhi is suffering from extremely high levels of pollution, being one of the world's leaders in poor air quality with extremely high amounts of PM2.5, PM10 and other noxious chemicals and smoke permeating the atmosphere. The main sources of air pollution in Delhi include vehicle exhaust, heavy industry such as power generation, small-scale industries like brick kilns, suspended dust on the roads due to vehicle movement and construction activities, open waste burning, combustion of fuels for cooking, lighting, and heating, and in-situ power generation via diesel generator sets. Stubble burning is one of the major contributors to atmospheric pollution in the world releasing particulate and gaseous pollutants that have severe effects on human health and the environment.

Literature Review

Delhi, the capital city of India, is inhabitants of approximately 16.7 million people. It is also the third largest urban agglomeration in the world. Governments are highly expected to get involved in the control and reduction of smoke emission, little has been informed about why governments shall take part in, and how governments can do better. Transport sectors contributes around three fourth of pollutants in all of Delhi. Vehicular sources alone generate more than 3000 metric tons of pollutants pes day. Climate also plays an important role determining level of pollutants at Delhi. A crop residue burning of 500 million tons during winter in surroundings of Delhi causes smog formation because of inversion. Central pollution Control Board had noted many of the establishment had inert pollution control devices and short chimney. Modernization of agriculture and non-availability of farm labour are also major factor of paddy straw burning. Thick black smog covers the area during burning and is responsible for health problems and environment degradation. Large-scale burning of farm residues (straw and stubble) from paddy–wheat farming systems is an issue of grave concern that results in GHG emissions in addition to causing atmospheric pollution, health risks, and removal of nutrients from the soil in the burned areas. Emissions calculations are needed to assess the impacts of residue burning in terms of health hazards, climate change, global warming, etc. This affects the health of the people land can cause major health pa problems like chronic respiratory diseases and asthma. In Delhi, poor quality air irreversibly damages the lungs of 2.2 million or 50 percent of all children.

1.. According to paper ‘Review of Air Quality Monitoring: Case Study of India' by Humaib Nasi, Kirti Goyal and Dolonchapa Prabhakar Delhi is considered to be most polluted in India with lot of vehicular emissions and thermal power plants releasing SPM, hydrocarbons, CO, sulphur, oxides of nitrogen and carbon monoxide11. Air pollution load (tonnes/day) from thermal plants is given in Table 1. As per National Ambient Air Quality Standards (NAAQS) level of SO2 and NO2 was found to be lower in all monitored periods but RSPM and SPM levels were found to be cooperatively exceeding. in addition to these other pollutants found in the area was carbon monoxide (CO) whose level was very high in initial years but it has lowered to some extent due to follow up of pollution control measures in city. The concentration of pollutants were found to be higher in winter seasons but were moderate in summer and lower in monsoon seasons. As per 2005 NAAQS survey, concentration of pollutants found is given in Table 2.

Table 1: Concentration of Pollutants from Thermal Plants at Delhi

Thermal Capacity	SOx	NOx	PM (without control device)	PM (without control device)
1083	61	91	3242	162

(**Source:** Present scenario of air quality in Delhi: a case study of CNG implementation’ by P. Goyal and Sidhartha)

Table 2: Concentration of Pollutants found at Delhi

Pollutants	Concentration (µg/m3)
SO2	11
NO2	48
RSPM	130
SPM	290

(**Source:** Review of Air Quality Monitoring: Case Study of India' by Humaib Nasi, Kirti Goyal and Dolonchapa Prabhakar)

2.. According to the paper named as ‘Present scenario of air quality in Delhi: a case study of CNG implementation’ by P. Goyal and Sidhartha, with the number of vehicles, especially two wheelers, increasing at an unprecedented rate, vehicular pollution has become a major contributor to deteriorating air quality in Delhi. According to White Paper (MOEF), vehicular pollution contributes to 64% of the total pollution in Delhi in 1991 and 70% in 2000–2001. And also the annual mean value of SO2 (14–15) mg/m³ and NOX(29–68) mg/m³ are within the prescribed limits of (60–80)mg/m³ and 8 hourly mean of CO (4.2–4.6)mg/m³ is within the limits of 5.0 mg/ m³ (Table 2.1). Compared to 1989, SO2 atmospheric concentration in 1996 has registered a 109% rise and NOX an 82% rise. The SPM’s atmospheric concentration has shown only a nominal rise, because of the installation of electrostatic precipitators by the thermal power plants in Delhi.

Table 3: National ambient air quality standards

pollutants	Time weigthed average	Concentration in ambient air			Method of measurement
		Sensitive area (µgm-3)	Industrial area (µgm-3)	Residential, rural and other areas (µgm-3)	
Sulphur dioxide (SO2)	Annual Average	15	80	60	Improved west and Geake method
	24 h	30	120	80	
Oxides of Nitrogen (NO2)	Annual	15	80	60	Jacob and Hochheiser modified (Na-Arsenite) method
	24h	30	120	80	
Suspended particulate matter (SPM)	Annual	70	360	140	High volume sampling (average flow rate not < 1.1 m3/min)
	24h	100	500	200	
Respirable particulate matter (RPM) (size < 10µm)	Annual	50	120	60	Respirable particulate matter sampler
	24h	75	150	100	

Lead (Pb)	Annual	0.5	1	0.75	ASS method after sampling using EPM 2000 or equivalent filter paper
	24h	0.75	1	1	
Carbon Monoxide	8h	1000	5000	2000	Non-dispersive infrared spectroscopy
	1h	2000	10000	4000	

(**Source:** Central Pollution control board, Delhi, 1994).

3. As per written in paper 'Stubble burning: Effects on health & environment, regulations and management practices' by Muhammad Isa Abdurrahman, Sukalpaa Chaki and Gaurav Sain, the crops mostly cultivated in India include; rice (Oryza sativa), wheat (*Triticum aestivum*), sugarcane (*Saccharum officinarum*), cotton (*Gossypium hirsutum*), jute (*Corchorus olitorius*) and mesta (*Hibiscus cannabinus*), Coarse Cereals (*Sorghum* (*Sorghum bicolor*), *maize* (Zeamays), millet (*Panicum miliaceum*), pearl (*Pinctada margaritifera*), and barley (*Hordeum vulgare*)), total pulses (gram (*Cicer arietinum*), moong (*Vigna radiate*), urad (*Vigna mungo*), pigeon-pea (*Cajanus cajan*)), and the other cereals (Soybean (Glycine max), sunflower (*Helianthus annuus*), rapeseed (*Brassica napus*) and Mustard (*Brassica nigra*), groundnut (*Arachis hypogaea*), castor seed (*Ricinus communis*), and sesame (*Sesamum indicum*)) (Jain *et al*., 2014). The highest stubble is generated from rice production as illustrated in table below.

Table 4: Types and quantities of crops commonly generated in India (Jain *et al*., 2014).

Type of crop	Quantity of Crop Produced (Mt/year)	Quantity of Stubble generated (Mt/year)	Ratio of stubble to crop
Rice	153.35	188.98	1.23
Wheat	80.68	120.07	1.49
Jute	18.31	31.51	1.72
Sugarcane	285.03	107.50	0.38
Maize	19.73	26.75	1.36
Cotton	37.86	90.86	2.40
Millet	17.62	21.57	1.22
Rape seed	7.20	17.28	2.40
Groundnut	7.17	11.40	1.59
Total	627.96	620.43	

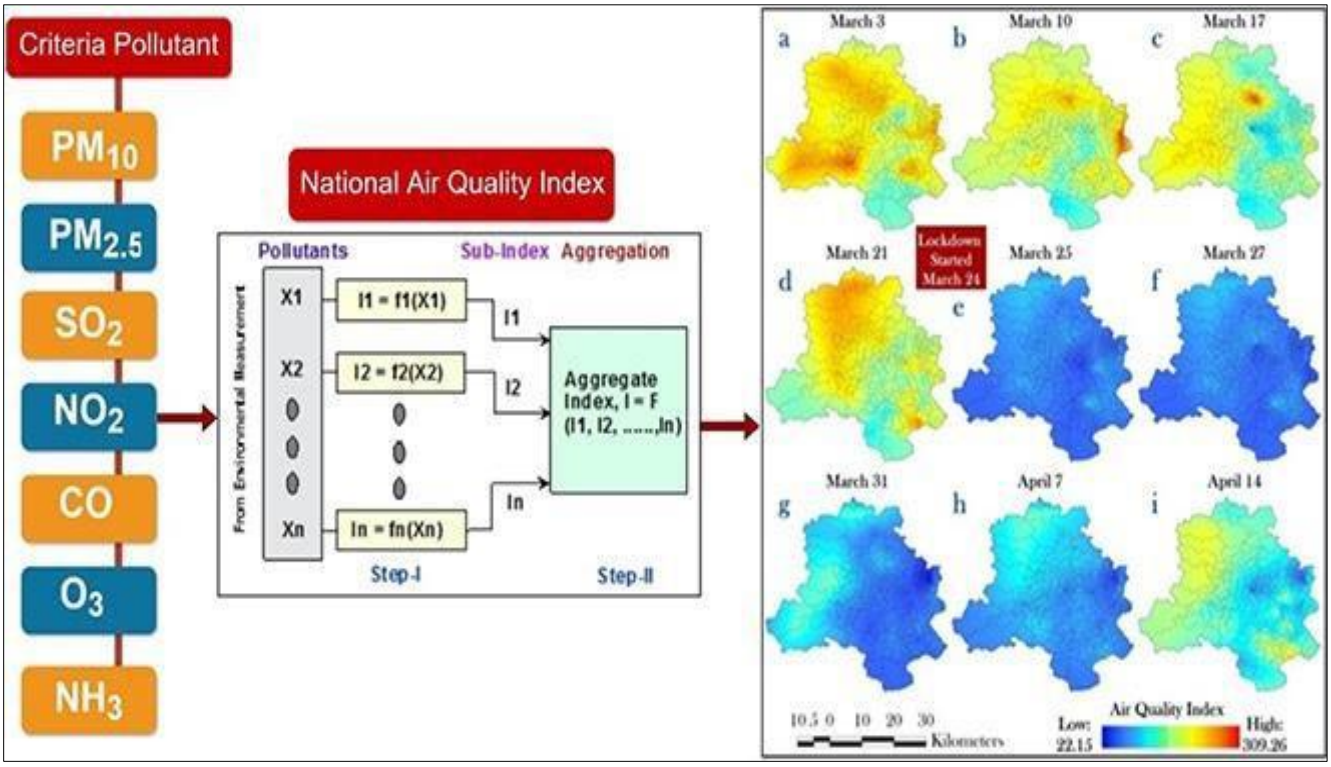
(**Source:** Stubble burning: Effects on health & environment, regulations and management practices by Muhammad Isa Abdurrahman, Sukalpaa Chaki and Gaurav Saini.)

Stubble burning is a significant source of carbon dioxide (CO2), volatile organic compounds (VOCs), nitrogen oxides (NOx) and hydrocarbons (HC) accounting for about 10% of the total emissions in the world (Liu *et al*., 2019). The emission contains particulate matter and harmful gases such as Nitrogen dioxide (NO2), N2O (Nitrous oxide), Sulphur dioxide (SO2), Carbon monoxide (CO), Carbon dioxide (CO2), and Methane (CH4), all of which severely affect human health. Sahai *et al*. (2011) gathered that upon burning of 63 Mt of the stubble, 3.4 Mt of CO, 0.1Mt of NOx, 91 Mt of CO2, 0.6 Mt of CH4, and 1.2 Mt of particulate matter are emitted. Another study established that burning 1 ton of stubble emits 199 kg of fly ash, 1460 kg of CO2, 60 kg of CO, 2 kg of0 SO2, and 3 kg of suspended particulate matters (SPM) (Gupta *et al*., 2004). Jain *et al*. (2014) demonstrated that emissions from stubble burning are mostly CO2 accounting for about 91.6% of the total emission.

Air pollution trends

India has been particularly vulnerable to air pollution over the last two decades, owing to population growth, increasing numbers of vehicles, use of fuels, inefficient transportation systems, poor land use patterns, industrialisation, and ineffective environmental regulations. Among Indian cities, the capital, New Delhi, is one of the worst-affected. New Delhi has the highest ambient particulate matter pollution exposure in the country. As of 2019, the average annual PM 2.5 concentration across India was 58.1 micrograms per cubic meter; Delhi's average PM 2.5 concentration for the year 2019 was 98.6 micrograms per cubic meter. The startling aspect of that statistic is that the recorded level is not just the highest for any capital city in India, but for any capital city in the world.

After Delhi went into lockdown in the wake of the pandemic, the pollution levels decreased drastically, and the air quality index returned to the 'satisfactory' level. Before this, Delhi's air was cleanest on 29 September 2019, when the AQI measured 60, which is 'satisfactory'. As shown on the Real-Time Air Quality Index, in Delhi, particulate matter (PM2.5) dropped from 165µg/m3 on 21 March 2020, a level considered unhealthy to everyone, to 64µg/m3 on 29 March 2020, 'moderate' or 'acceptable'. This is a sharp drop in air pollution for Delhi which usually records 'poor' to 'severe' levels of air quality with the AQI ranging from 100 to 300, and even higher in colder months



(**Source:** https://www.orfonline.org/research/air-pollution-delhi-filling-policy-gaps/?amp)

Fig 4: Change in NAQI in the NCT Delhi (3 March to 14 April 2020)

Table 5: Levels of PM10 and Air Quality Index during and after Lockdown

Phase of lockdown	PM 10 and Air Quality Index (AQI)
First Three Phases (March-May 2020)	The first three phases of the national lockdown, which started on March 25, led to large declines in air pollution in Delhi. In April 2020, the concentration of PM 10 fell to 71.7 µg/m3, less than half the concentration observed during the same month over the previous three years.
Fourth Phase (May-October 2020)	The concentration of PM 10 rose to 96.4 µg/m3 during the fourth phase of the lockdown, which expanded exemptions and permitted interstate movement starting May 18. But, shortly after lockdown restrictions were eased after May 18, a spike was recorded, and records indicated that Delhi's pollution patterns started climbing again. Delhi's air pollution levels increased by 43 percent in comparison to its best levels of air quality during the lockdown.
Post-Lockdown (October 2020 onwards)	To make matters worse, air quality in the Indian capital plummeted to an eight-month low on October 17, 2020. The air quality index (AQI) crossed 350 at various places, hovering between "very poor" and "severe" since then

(**Source:** https://www.orfonline.org/research/air-pollution-delhi-filling-policy-gaps/?amp)

The city experienced relatively cleaner air during the COVID-19 lockdown as industrial activity came to a halt. However, a drop in temperatures, coupled with the resumption of industrial operations and stubble burning by farmers after the harvest season, have raised pollution levels back up to dangerous levels. As Delhi has reopened, vehicles are back on the road, construction is restarting, and factories are reopening—air pollution, which had fallen to half the usual levels at this time of the year, is agaipractices.

Current Practices

Happy Seeder Machine

Happy seeder machine is a technique in which without burning rice paddy we can sow wheat crop into land. This technology saves water and makes soil Good. This technology is eco-friendly with environment. This machine structure is like a tractor which cuts and lifts rice straw. But after 2 years because of disadvantages many machines were dumped in the ground.

PUSA Decomposer

An organic composting solution have been developed by Indian Scientists so that farmers can use that solution as alternative to burning of crop stubble. At the Indian Agricultural Research Institute (IARI) at PUSA in New Delhi Microbiologist developed Capsules containing various fungi. The big problem with the IARI solution is that we have to chop crop stubble into very fine pieces to convert it into fertilizer.

Smog Gun

The Delhi Govt has also installed anti-smog guns at large construction sites in the national capital to control pollution as part of its air pollution monitoring plan, The smog guns are placed at 10 construction sites in Delhi.

Ban on construction of cards

As of now, authorities have not banned construction in Delhi NCR region. However, authorities have made it clear that measures such as a ban on construction activity, industries using

non- PNG fuels, and closure of thermal power plants will kick in when the air quality in the region hits emergency levels.

Ban of heavy vehiles

The State transport department has banned the entry of all heavy vehicles into the capital. All the vehicles, except the vehicles carrying perishable items like milk, fruits, vegetables and tankers carrying petroleum products, are asked to take an alternative route instead of entering the state

Conclusion

Air pollution in Delhi is a serious problem as it affects the lives of people. Few years before it was a major risk factor contributing severe diseases. Air pollution is the 5th largest killer in India. The quality of air in Delhi and areas connected to Delhi is problematic. Furthermore, Delhi is one of the most populated capital cities of the world. It causes high impact on children and senior citizens as they breathe this polluted air. Inhaling of this polluted air causes tremendous diseases such as asthma, headache, cough, fatigue, lungs cancer, etc. Burning of agricultural waste is one of the leading factors contributing in air pollution as it causes emission in the greenhouse gases. This greenhouse gases increases the global warming as well as it also increases the level of particulate matters and smog which leads to the degradation of soil fertility.

Hence it is has become necessary to find out major solutions for this problem of burning the stubble in open ground to reduce the hazard to human health from pollution.

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