AMITY UNIVERSITY
GURUGRAM

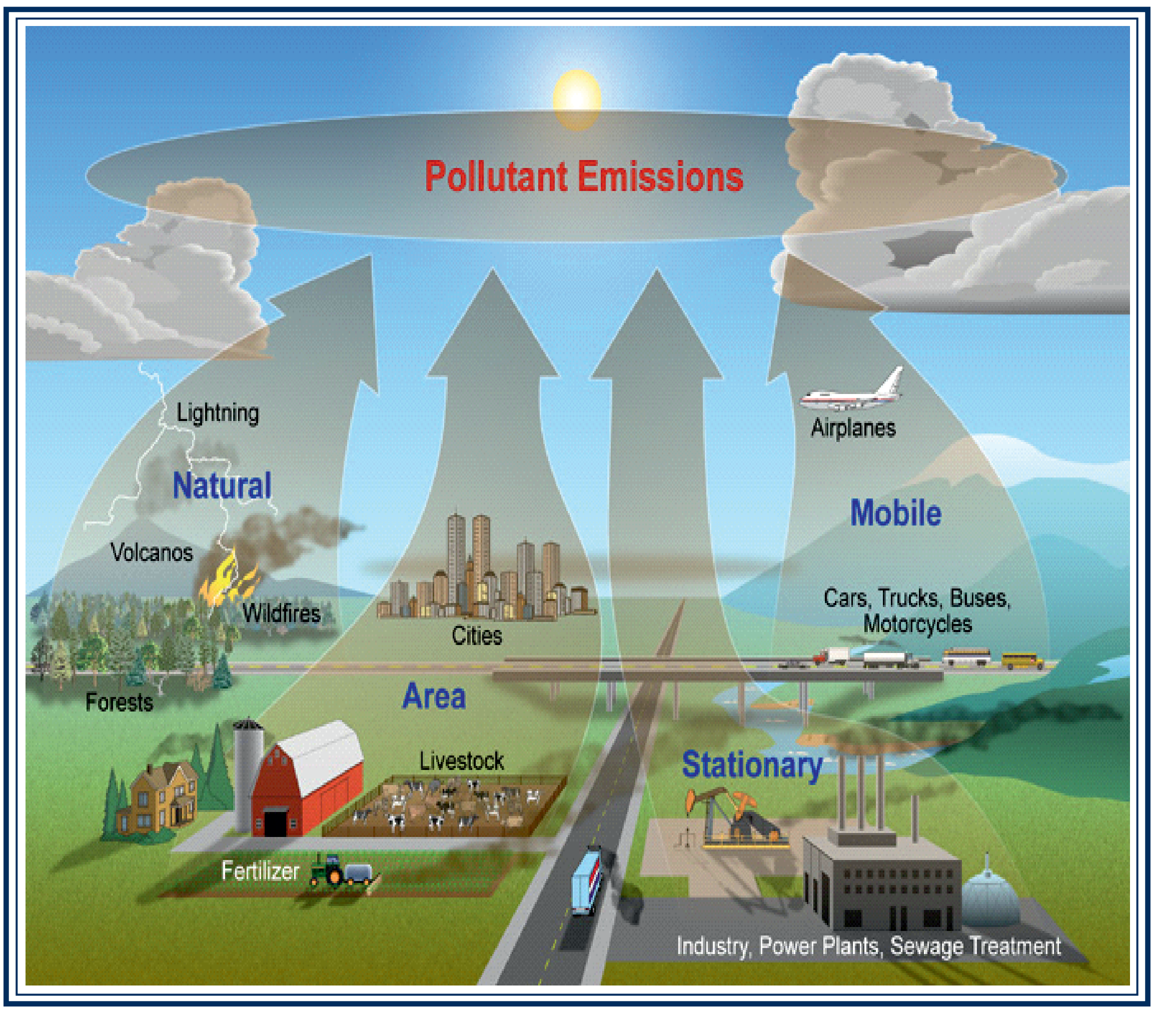
INTERNATIONAL SYMPOSIUM ON

AIR POLLUTION–CAUSES, MITIGATION & STRATEGIC PLANNING

BACKGROUND PAPER • 20TH SEPTEMBER, 2019

THE URBAN SOURCES OF POLLUTION

- Motorized traffic
- Industries (Thermal power plant, Industrial clusters)
- Domestic (Kitchen)
- Open biomass burning
- DG sets
- Construction dust
- Agriculture residue burning in surround rural area
- Re-suspension of road dust
- Transport of dust from surrounding area outside city



Source: Presentation of Prof. Mukesh Khare, Department of Civil Engineering, Indian Institute of Technology Delhi

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Foreword

Air Quality of Delhi and NCR region has been a matter of grave concern for the last few years. Alarms were raised when AQI touched 999 in the month of October 2016.The problem was further compounded with the crop residue *(Pallari)* being burnt by farmers of the NCR region that surrounds the capital city of Delhi. On that day it was found that the AQI was 14 in New Jersey, 16 in Munich and 30 in London. It occurred to our mind that New York/New Jersey, London and Munich were as polluted or even worse than Delhi 1950s ,1960s and up to 1970s, but the timely interventions of the policy makers, planners and the government that recognized the problem with a sense of urgency and thus rolled out strategic policies and actions that resulted in mopping out both air and water pollution in these mega world cities.

With most of the Indian cities being repeatedly listed as the worst polluted cities of the world, the health of one-sixth of humanity living in India is at grave risk. New research and findings are constantly indicating severe impact of air pollution on life and health, in addition to the larger impact on the environment and Climate Change. On the other hand, in spite of significant worldwide progress made in improving air quality, 92% of the world's population still lives in places where air quality much exceeds the WHO guidelines. According to WHO Report 2018(6) an estimated 7 million deaths were associated with pollution. This cause of mortality accounts for 11.6 per cent of all global deaths.

As far as India is concerned, on one hand we have great opportunities of accelerating India's economic growth to make it $5.0 Trillion Economy by 2024, on the other we have a monumental challenge of tackling of Air and Water Pollution. India with its 14 out of 15 world's most polluted cities has a gigantic task of mopping out Air Pollution from its mega cities, state capital and satellite towns. A sense of great urgency and strategic actions on war footings are required to put the house in order.

The case studies of New Jersey, London, China and Singapore are highly revealing as they provide a window to the utmost seriousness with which the problem of Air pollution is to be addressed through a well planned strategic vision and well monitored execution of the action plan. Singapore and China should provide a great learning experience for us as to how the monster of Air Pollution is taken head-on and on a fast track, the nation is to be pulled out of the disaster of our own making, while the tempo of economic growth is sustained. Beijing, the Capital of the most populated and prosperous country of the world, that was leveled as one of the 20 most polluted city in the world in 2013, today is out of the list of 200 most polluted cities of the world with PM 2.5 staying around 42.6 on annual average.

Recognizing the urgency to tackle the monumental challenge of Air Pollution in Delhi, soon after the festival of Diwali in October 2016 when AQI shot up to 999, the Govt of Delhi went into rationing its vehicular traffic by implementing Odd-Even Phase-I in January 2016 and again Odd-Even Phase-II in April 2016. ***AUH conducted its Air Quality Studies during the Odd-Even Phases and its report clearly established that significant improvement in AQI in capital city of Delhi was achieved, partly due to reduced traffic density and partly due to better driving conditions, cutting down travel time for commuters and near absence of traffic jams during these rationing periods.*** However the efforts were mocked by some as the western disturbance, bringing dust storm in April 2016 deprived the benefits of improved air quality due to sudden increase in PM10 during Odd-Even Phase-II. Apparently, the pressures of public due to inconvenience of Odd-Even forced the Government to give up the idea Vehicular traffic rationing.

Now that India is sitting on a Air Pollution disaster, the present Government of India has accorded its top priority to tackle this monstrous problem, The Government of India, in January 2019 has commissioned the National Clean Air Program, NCAP 2019 that aims at cutting down air pollution by 30% from the levels of 2017 in the next five years. But the prime question is that whether NCAP could be further strengthened with even bigger aims and with more effective strategies and actions, now that we have reliable monitoring network and opportunities to implement innovative solutions backed by Artificial Intelligence embedded in our strategic actions and trying out revolutionary technology shifts in various sectors such as energy, automobile and industries.

At the present symposium it is our considered view that the need for the strategic policy framework and actions on war footing cannot be over emphasized. As such we shall explore and adopt a positive approach to brainstorm on solutions that shall cause a quantum improvement in Air Quality in the most polluted cities of India, that include Delhi and its 04 satellite towns in NCR, namely, Gurugram, Faridabad and Ghaziabad.

September 20, 2019

Dr. Qamar Rahman
Distinguished Scientist
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Prof. P.B. Sharma
Vice Chancellor, AUH

1.0 Introduction:

Air Quality of Delhi and NCR region has been a matter of grave concern for the last few years. Alarms were raised when AQI touched 999 in the month of October 2016 (1).The problem was further compounded with the crop residue *(Pallari)* being burnt by farmers of the NCR region that surrounds the capital city of Delhi. On that day it was found that the AQI was 14 in New Jersey, 16 in Munich and 30 in London. It occurred to our mind that New York/New Jersey, London and Munich were as polluted or even worse than Delhi 1950s ,1960s and up to 1970s, but the timely interventions of the policy makers, planners and the government that recognize the problem with a sense of urgency and thus rolled out strategic policies and actions that resulted in mopping out both air and water pollution in these mega world cities.

The case study for New Jersey(2) clearly reveals the strategic frame work that resulted into sub-urbanization of the state that prompted shifting of people and also industrial and business activities. The advent of 1966 Thanks Giving New York City SO2 and PM episode, which was estimated to have shortened 366 people in New York City prompted the express urgency that brought out the 1970 Clean Air Act that further paved the way for developing National Ambient Air Qualities Standards, NAAQ and implementing emissions regulations and control strategies, USEPA 2010A. The use of better quality of fuel and also the major swift from coal to oil and subsequently to gas for industrial and domestic applications including Central Heating Systems, resulted into significant improvements in Ambient Air Quality as well as Indoor Air Pollution The pressure of compliance to Global Air Quality guide lines as defined by WHO continue to play an important role in enforcement of Air Quality Act as revised time to time. No wonder that AQI for most part of the year in NY/NJ remains within the prescribed limits of 20. The case studies on London (3), Singapore (4) and China (5) also provide a great learning experience to chart out strategic policies and actions that can help India address its monumental challenge of Air Pollution.

Getting alarmed by the AQI rising to 999 in many parts of Delhi and even New Delhi, drastic steps like Odd-Even Vehicles on alternative days in Delhi were introduced to demonstrate their impact on the Air Quality. The coal based power plants have also been targeted as they contributed heavily to particulate matter in air. The National Green Tribunal (NGT) has also came down heavily on construction agencies as construction activities in and around Delhi were also identified as a major source of particulate matter in Air. All these measures are still falling short for drastically reducing the particulate matter in Delhi and in the NCR region, as AQI still remains above 200 during most part of the year while the Global standards require AQI to be below 20.

With most of the Indian cities being repeatedly listed as the worst polluted cities of the world, the health of one-sixth of humanity living in India is at grave risk. New research and findings are constantly indicating severe impact of air pollution on life and health, in addition to the larger impact on the environment and Climate Change. On the other hand, in spite of significant worldwide progress made in improving air quality, 92% of the world's population still lives in places where air quality much exceeds the WHO guidelines. According to WHO Report 2018(6) an estimated 7 million deaths were associated with pollution. This cause of mortality accounts for 11.6 per cent of all global deaths.

As far as India is concerned, on one hand we have great opportunities of accelerating India's economic growth, on the other we have a monumental challenge of taking head on the monster of Air and Water Pollution. India with its 14 out of 15 world's most polluted cities has a gigantic task of mopping out Air Pollution from its mega cities, state capital and satellite towns. A sense of great urgency and strategic actions on war footings are required to put the house in order.

More urgent efforts are therefore needed to develop and implement the policies, investment programs and technologies needed to drastically reduce the sources of air pollution, be it industries, power plants, construction activities or vehicular emissions. At the time concurrent actions are required to clean the blue sky with which India was on a blessed due to its tropical troposphere for millions of years. We need to closely look into the international experience as to how Singapore, US, UK, countries of Europe and lately China have been able to achieve their goals of compliance to Global standards of Air Quality while making impressive industrial growth. The case studies of some of the countries are summarized here to provide a window on the strategies and actions taken.

Recognizing the urgency to tackle the monumental challenge of Air Pollution in Delhi, soon after the festival of Diwali in October 2016 when AQI shot up to 999, the Govt of Delhi went into rationing its vehicular traffic by implementing Odd-Even Phase-I in January 2016 and again Odd-Even Phase-II in April 2016. ***AUH conducted its Air Quality Studies during the Odd-Even Phases and its report clearly established that significant improvement in AQI in capital city of Delhi was achieved, partly due to reduced traffic density and partly due to better driving conditions, cutting down travel time for commuters and near absence of traffic jams during these rationing periods.*** However the efforts were mocked by some as the western disturbance, bringing dust storm in April 2016 deprived the benefits of improved air quality due to sudden increase in PM10 during Odd-Even Phase-II. Apparently, the pressures of public due to inconvenience of Odd-Even forced the Government to give up the idea Vehicular traffic rationing.

Now that India is sitting on a Air Pollution disaster, the present Government of India has accorded its top priority to tackle this monstrous problem, The Government of India, in January 2019 has commissioned the National Clean Air Program, NCAP 2019 (7) that goals at cutting down air pollution by 30% from the levels of 2017 in the next five years. But the prime question is that whether NCAP could be further strengthened with even bigger aims and with more effective strategies and actions, now that we have reliable monitoring network and opportunities to implement innovative solutions backed by Artificial Intelligence embedded in our strategic actions and trying out revolutionary technology shifts in various sectors such as energy, automobile and industries.

At the present symposium it is our considered view that the need for the strategic policy framework and actions on war footing cannot be over emphasized. As such we shall explore and adopt a positive approach to brain storm on solutions that shall cause a quantum descent in AQI in the most polluted cities of India, that include Delhi and its NCR satellite town of Gurgaon, Faridabad and Ghaziabad.

2.0 Air Pollution Parameters:

According to the US Environmental Protection Agency (EPA), criteria pollutants are the particulate matter such as PM1, PM2.5 and PM10, photo-chemical oxidants and ground level ozone, carbon- monoxide, sulphuroxides, nitrogenoxides and lead. These pollutants are responsible for causing serious health hazards, environnemental hazards such as, smog, acid rain, and property damage etc. These pollutants are termed as criteria pollutants because as per the Clean Air Act, 1963, US EPA sets National Ambient Air Quality Standards based on the human health-based and/or environmentally-based criteria. The sources and effects of criteria pollutants are given below in Table 1.

Much of the Air Quality research has focused on the levels of fine particulate matter known as PM2.5. These microscopic particles are 20 times smaller than the width of a human hair and are the most damaging to human health. They can be metals, organic compounds or the by-products of combustion from coal-fired power stations, wood and charcoal-burning stoves, vehicle engines and factories as shown in (Fig. 1).

Figure 1: *Sources of Air Pollution (WHO Report 2018)*

Criteria pollutants	Emission sources		Major effects	
	Natural sources	Anthropogenic Sources	Healtheffects	Environmental effects
Sulfurdio xide (SO_2)	Volcanicem issions	Burning of fossil fuels, metal smelting ,petroleum refining *etc.*	Respiratory problems, heart and lung disorders, visual impairment	Acid rain
Nitrogendi oxie (NO_2)	Lightning, forest fires *etc.*	Burningof fossil fuels, biomass and high temperature combustion processes	Pulmonary disorders, increased susceptibility torespiratory infections	Precursor of ozone Formation in troposphere, aerosol formation
Particulatem atter (PM)	Wind blown dust, pollen spores, photo-chemically produced particles	Vehicular emissions, industrial combustion processes, commercial and residential combustion, construction Industries	Respiratory problems, liver fibrosis, lung/livercancer, heart stroke, bone problems	Visibility reduction
Carbonmon oxide (CO)	Animal metabolism, forest fires, volcanicactivity	Burning of carbonaceus fuels, emission from IC engines	Anoxemia leadingtovarious Cardio vascular problems. Infants, pregnant women, and elderly people are at higher risk	-
Ozone (O_3)	Present in stratosphere at 10 – 50 km height	Hydrocarbons and NO_X upon reacting with sunlight results in O_3 formation	Respiratory problems, asthma, bronchitis*etc.*	O_3 in upper Troposphere causes green house effects, harmful effects on plants as it interferes in photo synthesis and results in death of plant tissues since it assists in the formation of Peroxyacetylnitate (PAN)
Lead (Pb)	-	Metal processing plants, waste incineration, automobile exhausts, lead-acid batteries, industrial effluents *etc.*	Seriouseffects on Central nervous system sinceitis absorbedrapidly in blood stream, anemia, toxic for soft tissues and bones.	-

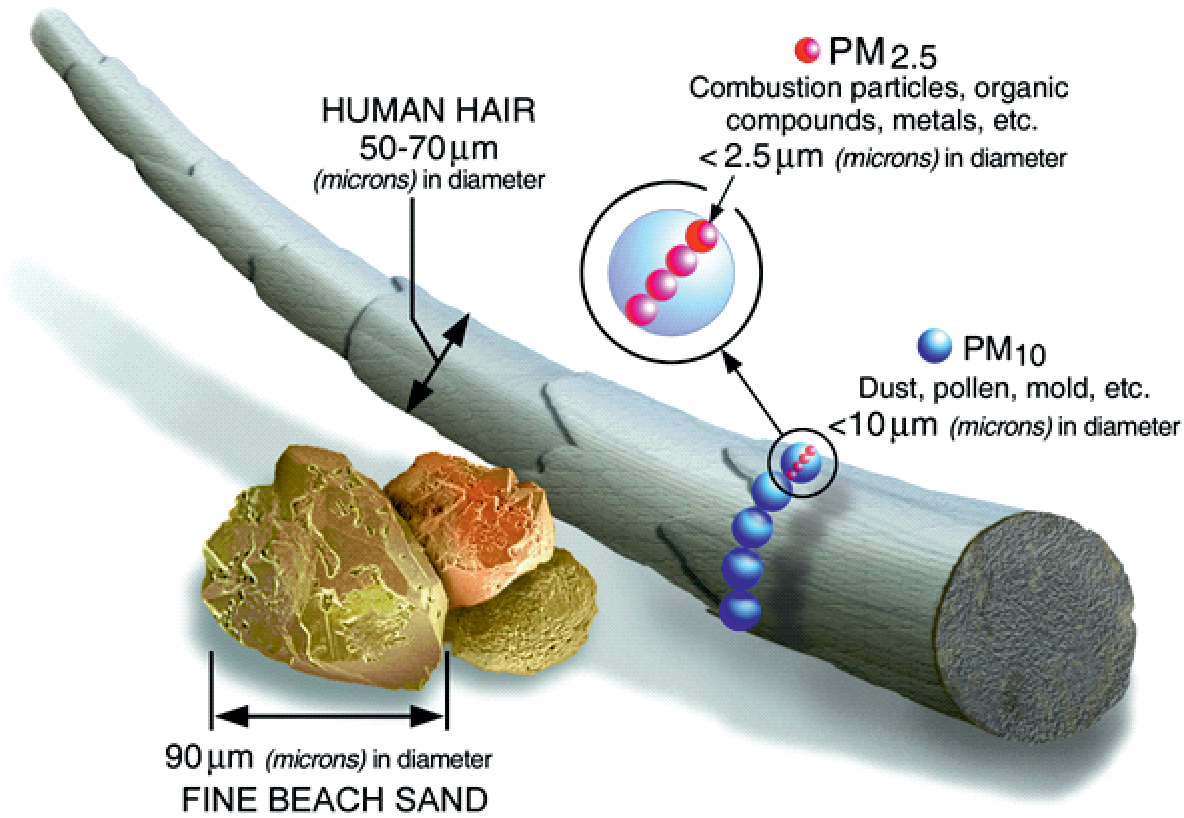


Figure 2: *Size comparison of different particular matters.*

3.0 Deaths and Mortality due to Air Pollution (6)

Air pollution levels remain dangerously high in many parts of the world. New data from the World Health Organization (WHO) released on 2nd of May 2018 (6), shows that 9 out of 10 people breathe air containing high levels of pollutants. Updated estimations reveal an alarming death toll of 7 million people die every year from exposure to fine particles in polluted air that penetrate deep into the lungs and cardiovascular system, causing diseases including stroke, heart disease, lung cancer, chronic obstructive pulmonary diseases and respiratory infections, including pneumonia.

"Air pollution threatens us all, but the poorest and most marginalized people bear the brunt of the burden," said Dr Tedros Adhanom Ghebreyesus, Director-General of WHO as per the news release of WHO, May 2, 2018. "It is unacceptable that over 3 billion people – most of them women and children – are still breathing deadly smoke every day from using polluting stoves and fuels in their homes. If we don't take urgent action on air pollution, we will never come close to achieving sustainable development.", the WHO said.

7 million deaths every year

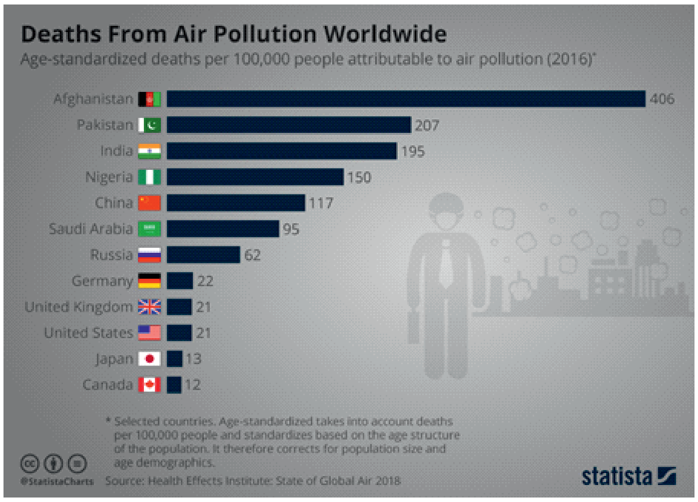


Figure 3: *Countries having most number of deaths due to pollution (Health Effect Institute, State of Global Air)*

As per WHO 2018, ambient air pollution alone caused some 4.2 million deaths worldwide in 2016, while household air pollution from cooking with polluting fuels and technologies caused an estimated 3.8 million deaths in the same period.

India with its 14 out of 15 world's most polluted cities India occupies 3rd place in the list of most number of deaths of people due to air pollution as given in Fig. 3.

Air Pollution kills an average of 8.5 out of every 10.000 children in India before they turn five (WHO 2018). The risk is higher for girls as 9.6 out of 10, 000 girls die before five.

More than 90% of air pollution-related deaths occur in low- and middle-income countries, mainly in Asia and Africa, followed by low- and middle-income countries of the Eastern Mediterranean region, Europe and the Americas.

WHO recognizes that air pollution is a critical risk factor for non-communicable diseases (NCDs), causing an estimated one-quarter (24%) of all adult deaths from heart disease, 25% from stroke, 43% from chronic obstructive pulmonary disease and 29% from lung cancer.

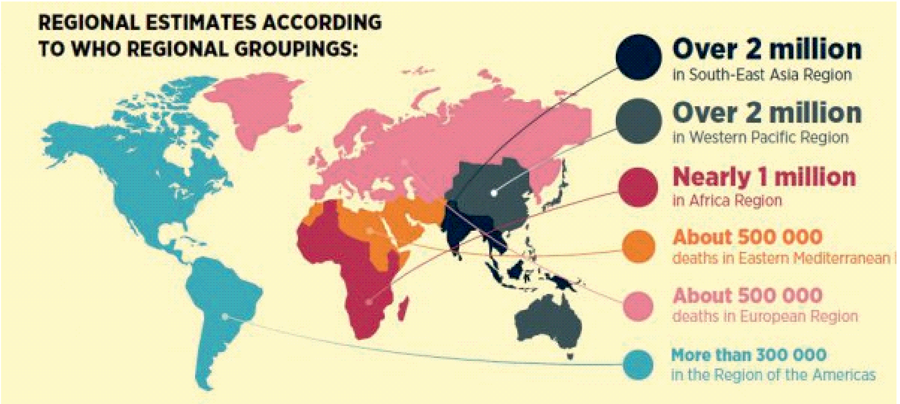


Figure 4: *Region-wise number of deaths (WHO 2016-2018)*

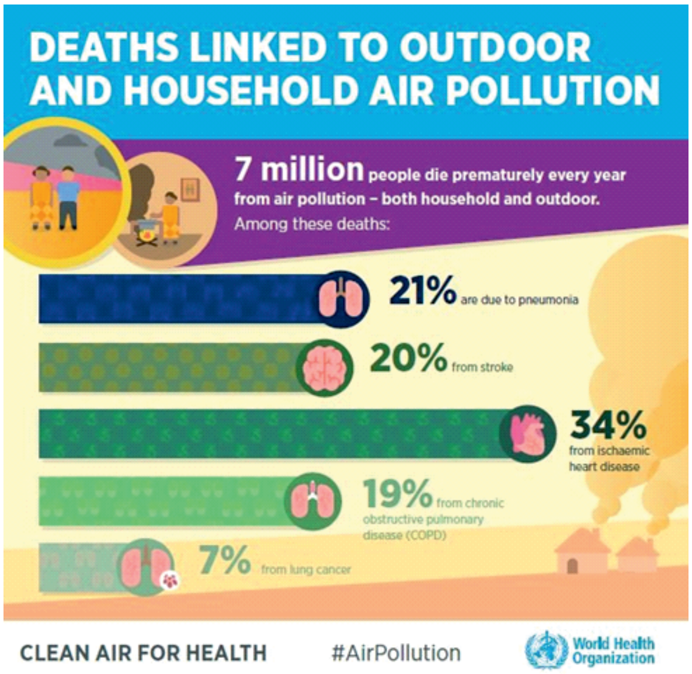


Figure 5: *Causes of deaths due to Air Pollution (WHO 2016-2018)*

Life expectancy in India has gone down by 2.6 years due to deadly diseases caused by air pollution, a recent report by CSE has found CSE further revealed that outdoor and household air pollution together are causing deadly diseases. "Air pollution is now the third highest cause of death among all health risks ranking just above smoking in India. This is a combined effect of outdoor particulate matter (PM) 2.5, ozone and household air pollution", CSE Report 2019 says CSE Report (8).

4.0 Deadly combination

Due to this combined exposure, South Asians, including Indians, are dying early, their life expectancy has reduced by over 2.6 years. This is much higher than the global tally of reduced life expectancy by an average of 20 months. While globally a child born today will die 20 months sooner on an average than would be expected without air pollution in India they would die 2.6 years earlier," as per the report by the CSE8.

While exposure to outdoor particulate matter (PM) accounted for a loss of nearly one year and six months in life expectancy, exposure to household air pollution accounted for a loss of nearly one year and two months, according to the CSE. "Thus, together Indians lose 2.6 years," CSE says.

"The deadly tally broken up by diseases shows that chronic obstructive pulmonary disease (COPD) due to air pollution at 49 per cent is responsible for close to half of deaths, followed by lung cancer deaths at 33 per cent, diabetes and ischemic heart disease at 22 per cent each and stroke at 15 per cent. It is disturbing how COPD, lung cancer and ischemic heart disease dominate the dubious tally," CSE study pointed out.

4.1 Head-to-toe harm is caused by Air Pollution (8)

The CSE report 2018 referred to two review papers by scientists from the Forum of International Respiratory Societies and said air pollution can harm acutely as well as chronically, potentially affecting every organ in the body. "According to the study, ultra-fine particles pass through lungs are taken up by cells and carried via the bloodstream to expose virtually all cells in the body. Air pollution may be damaging every organ and virtually every cell in the human body, according to a comprehensive new global review recently reported. The research shows head-to-toe harm, from heart and lung disease to diabetes and dementia, and from liver problems, brain, intelligence, abdominal organs, reproduction, and bladder cancer to brittle bones and damaged skin. Fertility, fetuses and children are also affected by toxic air," CSE Report said.

5.0 The Global Perspective:

Air Pollution is one of the biggest Global environmental Challenges of today. The reports from the Intergovernmental Panel on Climate Change (IPCC) (9) and The United Nations Frame Work Convention on Climate Change (UNFCCC) (10) show that the anthropogenic activities are major culprit for this burning scenario.

After industrial revolution in many countries, this situation of bad air quality became more horrible and at present it's in continuation. The developed and under developed countries are the major emitters of Green House Gases (GHGs) which leads to Green House Effect (GHE) and hence Global Warming (GW) and Climate Change (CC).

The countries like China which is an upper low income country according to World Bank and India which is Low Middle Income Country are on their peak of economic and industrial development contribute as a leading emitter (11). The heavy population density is also a reason for emissions. Apart from that if we consider Bangladesh and Nepal which are Low Income Countries according to World Bank are also in the list of leading emitter as the rates of emissions of carbon dioxide (CO_2), Volatile Organic Compounds (VOCs) and other GHGs are very high due to industrial and vehicular exhaust, biomass and crop residue burning etc.

The results of the Climate Change Performance Index (CCPI) 2019 which monitors the performance of countries under Paris Agreement according to their Per-Capita Emissions and Per-Capita use of Non-Conventional Renewable Energy to minimize the long term impact of climate change. The CCPI 2019 shows that the developed countries like USA, Japan, Canada, Russia etc. are not performing well as they are in very week category although China, India and European Union (EU) are Medium and Good respectively (See Fig. 6 and Table 2). But when we see their individual score cards of CCPI 2019 reports, we get that the emissions in well-developed USA are stable or decreasing but in countries like Under Developed India and well developed China its increasing like anything although the EU which is also well developed decreases its emissions as in Table 2, as per CCPI 2019 (12) .

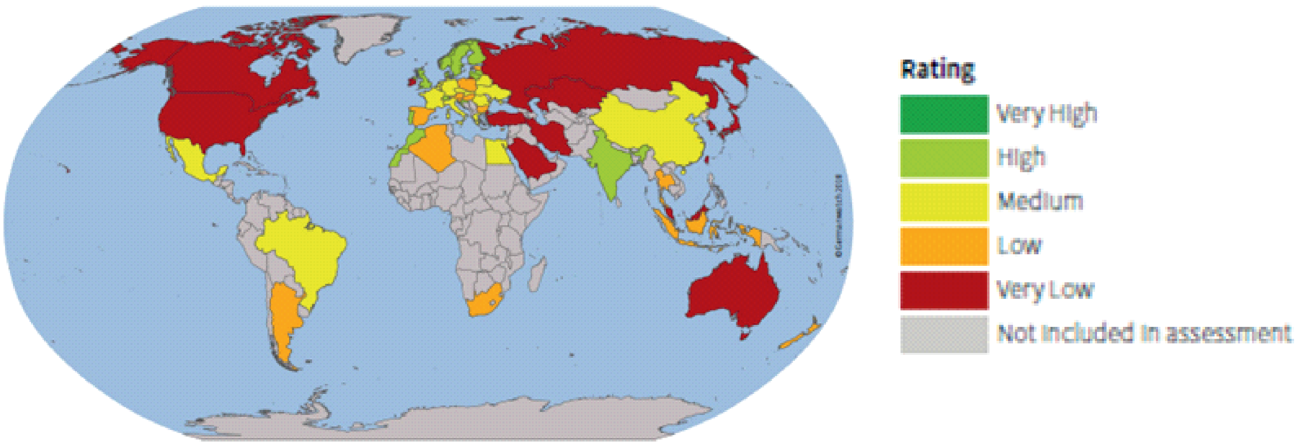
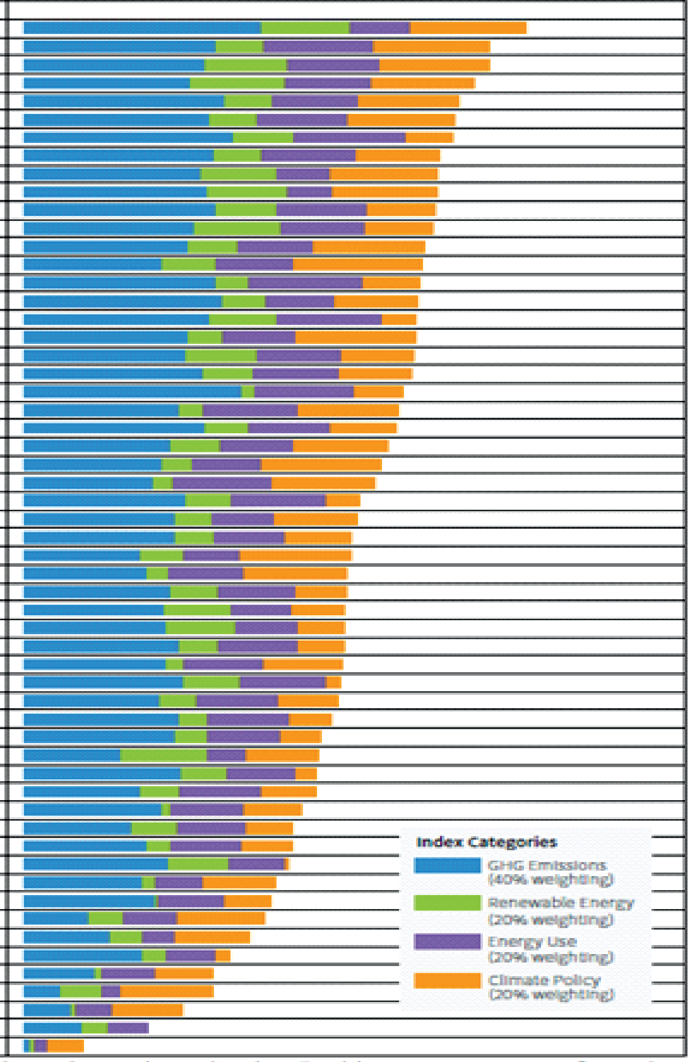


Figure 6: *The CCPI overall results 2019 (CCPI 2019)*

Table 2: Ranking of Countries according to CCPI Results 2019

Rank		Country	Score**
1.*		–	–
2.		–	–
3.		–	–
4.	–	Sweden	76.28
5.	▲	Morocco	70.48
6.	▼	Lithuania	70.47
7.	▲	Latvia	68.31
8.	–	United Kingdom	65.92
9.	▲	Switzerland	65.42
10.	▲	Malta	65.06
11.	▲	India	62.93
12.	▼	Norway	62.80
13.	▼	Finland	62.61
14.	▼	Croatia	62.39
15.	▲	Denmark	61.96
16.	▲	European Union (28)	60.65
17.	▲	Portugal	60.54
18.	▲	Ukraine	60.09
19.	▲	Luxembourg	59.92
20.	▲	Romania	59.42
21.	▼	France	59.30
22.	▼	Brazil	59.29
23.	▼	Italy	58.69
24.	▲	Egypt	57.49
25.	▲	Mexico	56.82
26.	▼	Slovak Republic	56.61
27.	▼	Germany	55.18
28.	▲	Netherlands	54.11
29.	▼	Belarus	53.31
30.	▲	Greece	50.86
31.	▲	Belgium	50.63
32.	▲	Czech Republic	49.73
33.	▲	China	49.60
34.	▲	Argentina	49.01
35.	▲	Spain	48.97
36.	▼	Austria	48.78
37.	▼	Thailand	48.71
38.	▼	Indonesia	48.68
39.	▲	South Africa	48.25
40.	▲	Bulgaria	48.11
41.	▼	Poland	47.59
42.	▲	Hungary	46.79
43.	▼	Slovenia	44.90
44.	▼	New Zealand	44.61
45.	▼	Estonia	44.37
46.	▼	Cyprus	44.34
47.	▼	Algeria	42.10
48.	▲	Ireland	40.84
49.	▲	Japan	40.63
50.	▼	Turkey	40.22
51.	▲	Malaysia	38.08
52.	▲	Russian Federation	37.59
53.	▲	Kazakhstan	36.47
54.	▼	Canada	34.26
55.	▲	Australia	31.27
56.	▼	Chinese Taipei	28.80
57.	▲	Republic of Korea	28.53
58.	▲	Islamic Republic of Iran	23.94
59.	▼	United States	18.82
60.	–	Saudi Arabia	8.82



*None of the countries achieved positions one to three. No country is doing enough to prevent dangerous climate change. ** rounded

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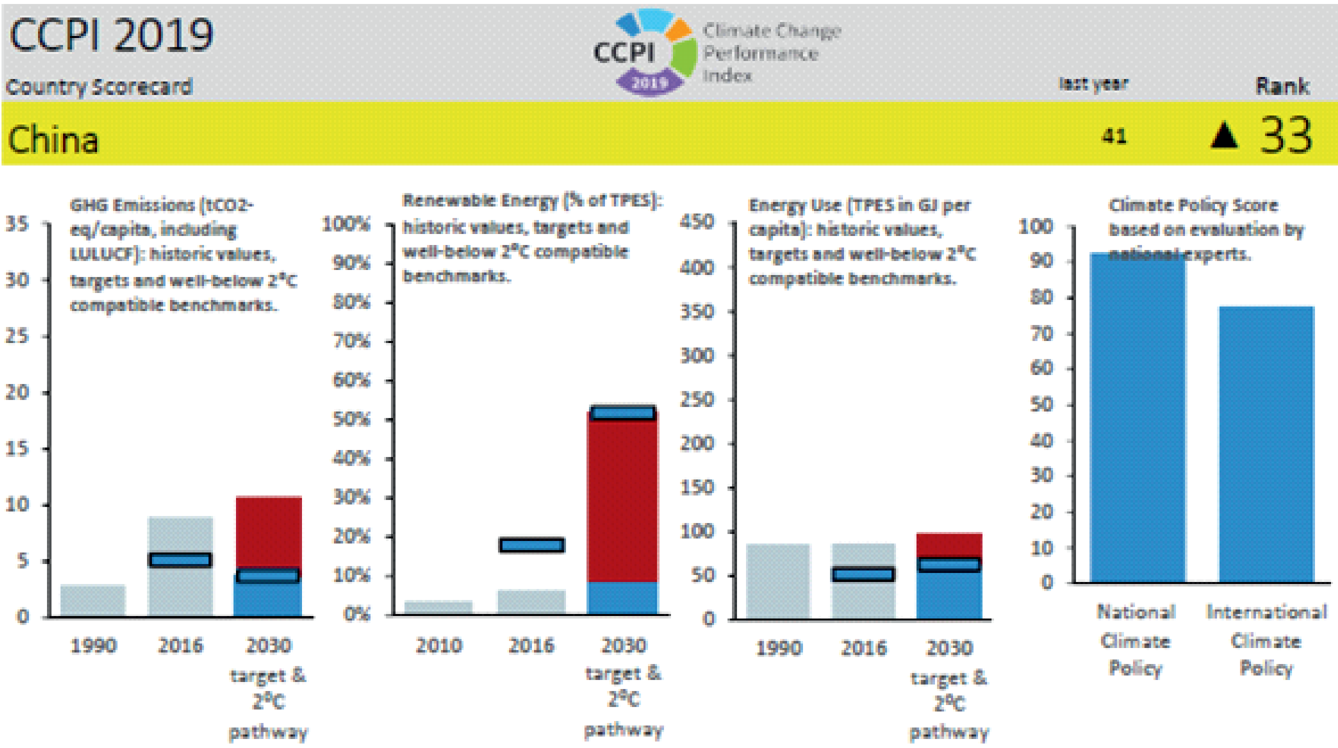
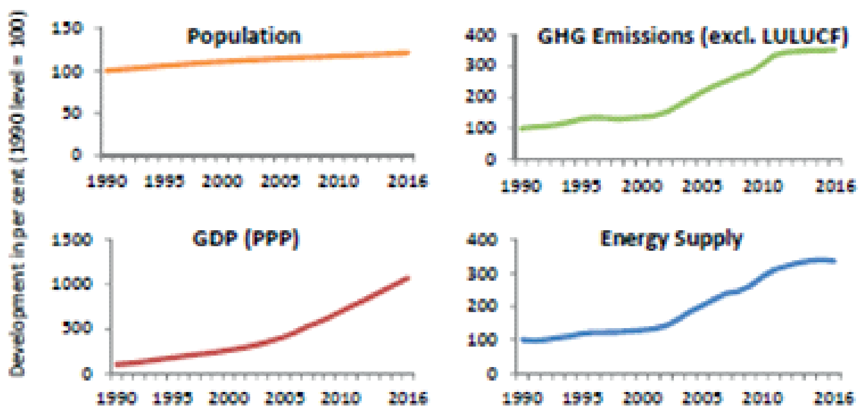


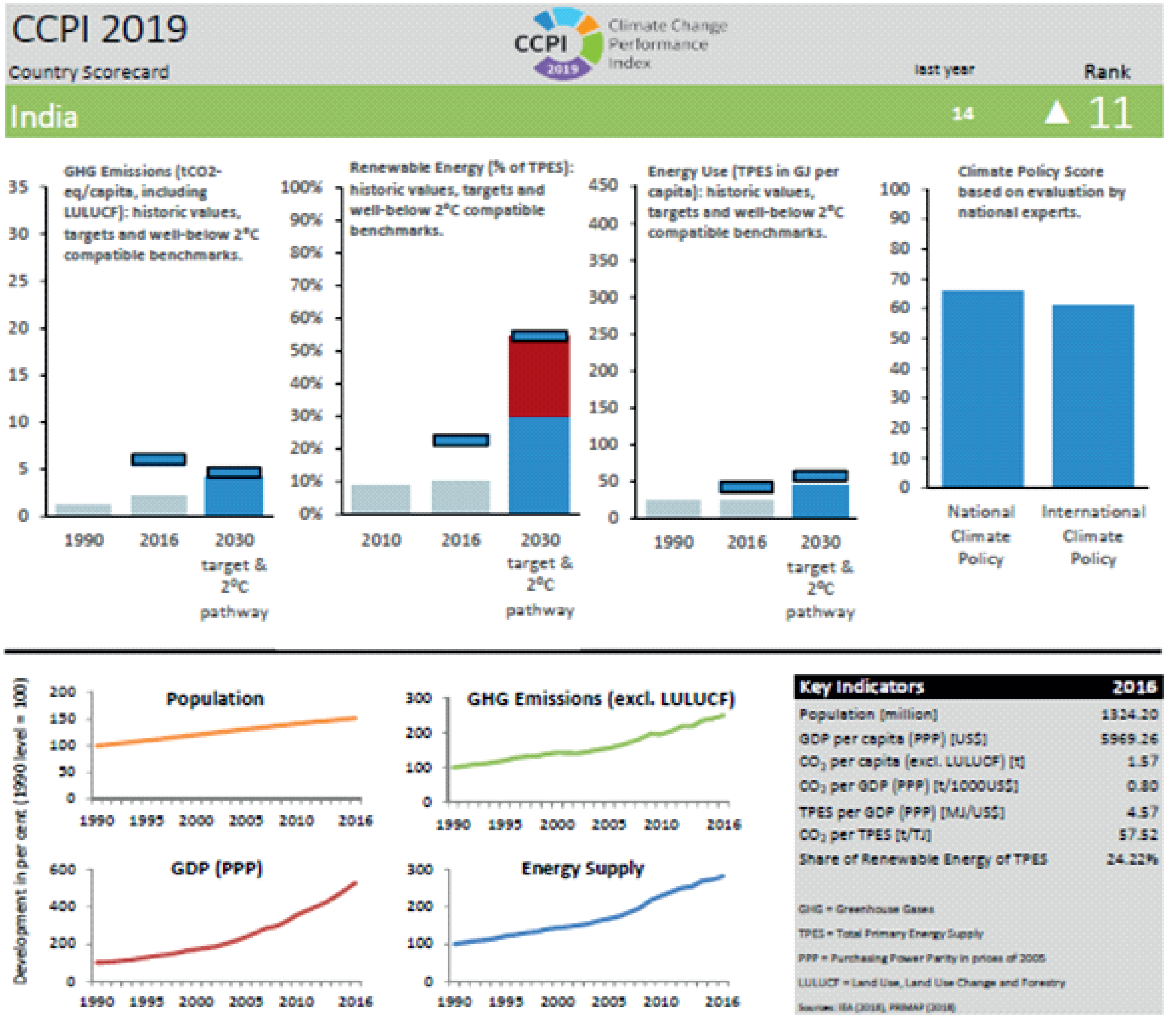


Key Indicators	2016
Population [million]	1386.00
GDP per capita (PPP) [US$]	14315.37
CO_2 per capita (excl. LULUCF) [t]	6.57
CO_2 per GDP (PPP) [t/1000US$]	0.90
TPES per GDP (PPP) [MJ/US$]	6.27
CO_2 per TPES [t/TJ]	73.13
Share of Renewable Energy of TPES	8.97%

GHG = Greenhouse Gases
TPES = Total Primary Energy Supply
PPP = Purchasing Power Parity in prices of 2005
LULUCF = Land Use, Land Use Change and Forestry
Sources: IEA (2018), PRIMAP (2018)

Indicators	Weighting	Score	Rank
GHG per Capita - current level (incl. LULUCF)	10%	60.4	37
GHG per Capita - current trend (excl. LULUCF)	10%	16.2	49
GHG per Capita - compared to a well-below-two-degrees benchmark	10%	41.0	47
GHG 2030 Target - compared to a well-below-two-degrees benchmark	10%	56.4	50
Share of Renewable Energy in Energy Use - current level (incl. hydro)	5%	14.9	38
Renewable Energy - current trend (excl. hydro)	5%	86.6	11
Share of Renewable Energy in Energy Use (excl. hydro) - compared to a well-below-two-degrees benchmark	5%	18.4	38
Renewable Energy 2030 Target (incl. hydro) - compared to a well-below-two-degrees benchmark	5%	15.7	48
Energy Use (TPES) per Capita - current level	5%	74.1	17
Energy Use (TPES) per Capita - current trend	5%	23.6	53
Energy Use (TPES) per Capita - compared to a well-below-two-degrees benchmark	5%	33.2	55
Energy Use (TPES) 2030 Target - compared to a well-below-two-degrees-benchmark	5%	37.9	50
National Climate Policy	10%	92.5	5
International Climate Policy	10%	77.4	14

Figure 7 (b): *Individual Score Card for CCPI 2019 of China*



Key Indicators	2016
Population [million]	1324.20
GDP per capita (PPP) [US$]	5969.26
CO_2 per capita (excl. LULUCF) [t]	1.57
CO_2 per GDP (PPP) [t/1000US$]	0.80
TPES per GDP (PPP) [MJ/US$]	4.57
CO_2 per TPES [t/TJ]	57.52
Share of Renewable Energy of TPES	24.22%

GHG = Greenhouse Gases
TPES = Total Primary Energy Supply
PPP = Purchasing Power Parity in prices of 2005
LULUCF = Land Use, Land Use Change and Forestry
Sources: IEA (2018), PRIMAP (2018)

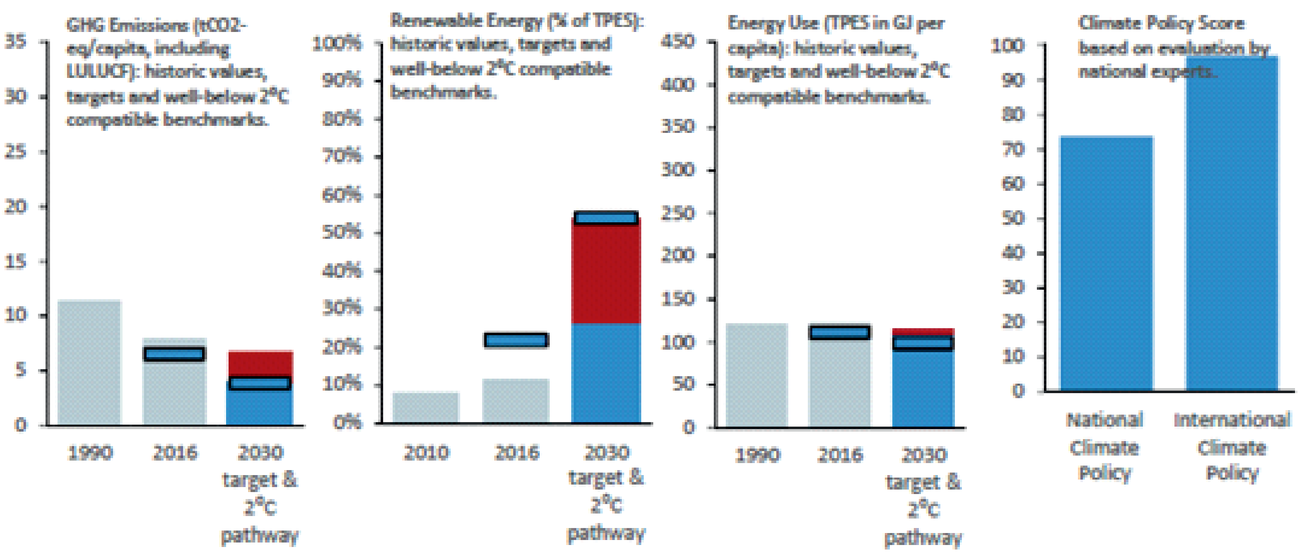
Indicators	Weighting	Score	Rank
GHG per Capita - current level (incl. LULUCF)	10%	94.9	5
GHG per Capita - current trend (excl. LULUCF)	10%	0.0	59
GHG per Capita - compared to a well-below-two-degrees benchmark	10%	93.2	5
GHG 2030 Target - compared to a well-below-two-degrees benchmark	10%	99.3	5
Share of Renewable Energy in Energy Use - current level (incl. hydro)	5%	23.7	26
Renewable Energy - current trend (excl. hydro)	5%	29.5	26
Share of Renewable Energy in Energy Use (excl. hydro) - compared to a well-below-two-degrees benchmark	5%	22.7	33
Renewable Energy 2030 Target (incl. hydro) - compared to a well-below-two-degrees benchmark	5%	64.2	12
Energy Use (TPES) per Capita - current level	5%	98.6	5
Energy Use (TPES) per Capita - current trend	5%	10.2	57
Energy Use (TPES) per Capita - compared to a well-below-two-degrees benchmark	5%	96.0	6
Energy Use (TPES) 2030 Target - compared to a well-below-two-degrees-benchmark	5%	84.2	11
National Climate Policy	10%	66.0	24
International Climate Policy	10%	61.3	27

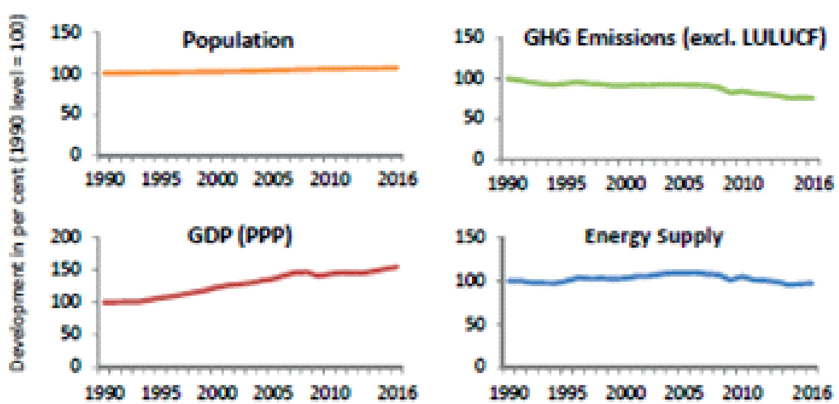
Figur 7 (c): *Individual Score Card for CCPI 2019 of India*

CCPI 2019
Country Scorecard

Climate Change Performance Index

European Union (28)	last year	Rank
	21	▲ 16





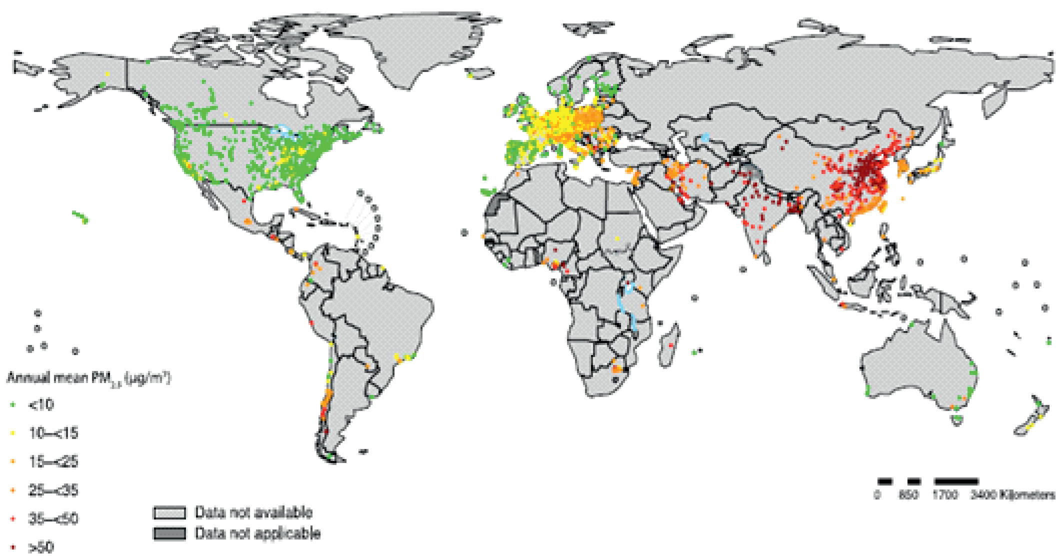
Key Indicators	2016
Population [million]	511.30
GDP per capita (PPP) [US$]	35469.59
CO_2 per capita (excl. LULUCF) [t]	6.24
CO_2 per GDP (PPP) [t/1000US$]	0.20
TPES per GDP (PPP) [MJ/US$]	3.69
CO_2 per TPES [t/TJ]	47.70
Share of Renewable Energy of TPES	13.55%

GHG = Greenhouse Gases
TPES = Total Primary Energy Supply
PPP = Purchasing Power Parity in prices of 2005
LULUCF = Land Use, Land Use Change and Forestry
Sources: IEA (2018), PRIMAP (2018)

Indicators	Weighting	Score	Rank
GHG per Capita - current level (incl. LULUCF)	10%	65.7	32
GHG per Capita - current trend (excl. LULUCF)	10%	43.2	21
GHG per Capita - compared to a well-below-two-degrees benchmark	10%	57.4	29
GHG 2030 Target - compared to a well-below-two-degrees benchmark	10%	80.3	27
Share of Renewable Energy in Energy Use - current level (incl. hydro)	5%	26.2	20
Renewable Energy - current trend (excl. hydro)	5%	28.3	27
Share of Renewable Energy in Energy Use (excl. hydro) - compared to a well-below-two-degrees benchmark	5%	38.7	17
Renewable Energy 2030 Target (incl. hydro) - compared to a well-below-two-degrees benchmark	5%	55.3	15
Energy Use (TPES) per Capita - current level	5%	58.2	38
Energy Use (TPES) per Capita - current trend	5%	47.3	25
Energy Use (TPES) per Capita - compared to a well-below-two-degrees benchmark	5%	65.5	30
Energy Use (TPES) 2030 Target - compared to a well-below-two-degrees-benchmark	5%	59.6	35
National Climate Policy	10%	73.6	22
International Climate Policy	10%	96.8	5

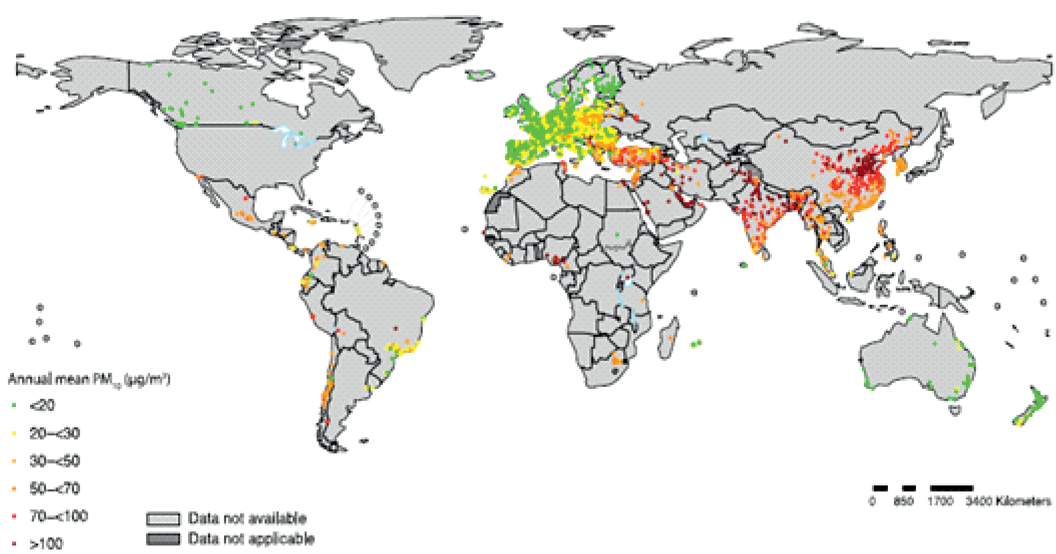
Figure 7 (c): *Individual Score Card for CCPI 2019 of EU*

After considering the World Health Organization's Ambient Air Pollution (AAP) and Household Air Pollution (HAP) databases a much drastic picture was appeared. The WHO having its own defined regions based on income of country which is provided by World Bank. The report of AAP Database shows that the concentrations of PM2.5 and PM10 between 2010-2016 is highest in China, India, Nepal, Bangladesh and Middle East (Fig.8 and Fig. 9). Some African Countries or Regions also in the same list (9).



$PM_{2.5}$: Fine particulate matter of a diameter of 2.5 microns or less.

Figure 8: *Monitoring Loctions of PM2.5 and Concetrations (WHO AAP 2016)*



PM_{10}: Fine particulate matter of a diameter of 10 microns or less.

Figure 9: *Monitoring Loctions of PM10 and Concetrations (WHO 2016)*

In 2017 India had nine of the world's 10 most polluted cities, according to one World Health Organization measure, with choking urban smog that researchers estimate killed 1.24 million people.

Now, in 2018, a new study by IQ Air Air Visual and Greenpeace has identified the cities where air pollution is highest. The list is dominated by India, with 15 of the worst 20 cities of the world 30 as shown in Fig 10.

In Jan 2019, when the Indian government's National Clean Air Program unveiled a five-year plan that environmentalists welcomed as long overdue but criticized as lacking clear mechanisms or robust funding to achieve its aims, which include reducing air pollution in 102 cities by up to 30 percent from 2017 levels (7).

The most polluted city on earth is Gurugram, a financial and industrial hub of nearly 1 million people situated about 30 kilometers southwest of New Delhi. There, average air pollution levels in 2018 were more than 13 times the level permitted under WHO guidelines, although air quality had actually improved slightly since the previous year (13).

Like Gurugram, the next four Indian cities on the list are satellites of Delhi, which are the most polluted capital on earth. Patna and Lucknow, along with Faisalabad and Lahore in Pakistan, and Hotan in China, make it to the worst 10 as per the WHO report (13).

6.0 India has the Most Polluted Cities On Earth

Average level of particulate matter (PM 2.5) pollution in 2018

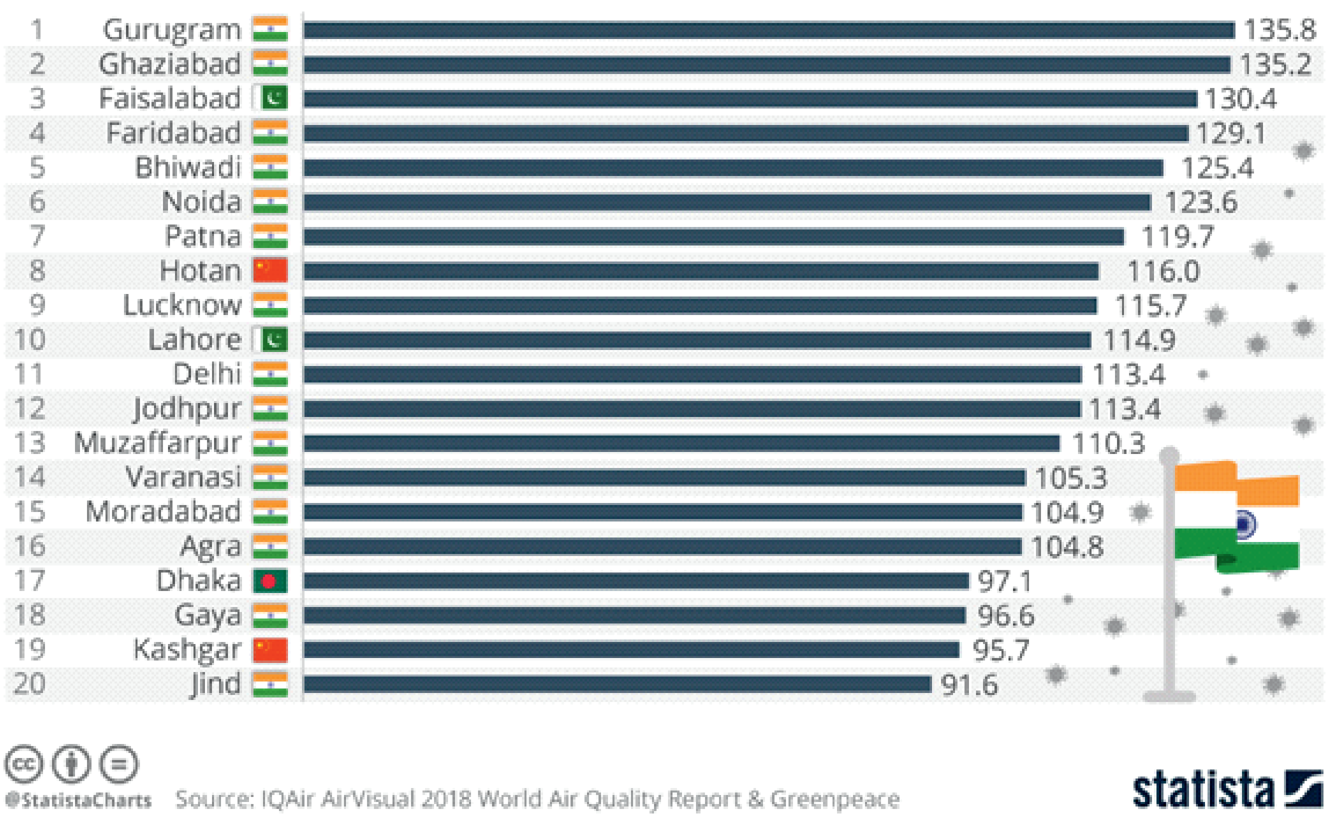


Figure 10: *Top 20 most polluted cities (IQAir Air Visual 2018 & Greenpeace)*

The Green Peace 2016 (14) report highlighted that PM10 concentrations are 268 µg/m3 for year 2015, which were at 4.5 times higher than the NAAQS annual limit set by CPCB (Fig. 11) and about 13 times the annual limit set by WHO for PM10. Detailed observation of the data suggests that the PM10 levels has been very high all around the year for 2015 for Delhi with October to February being the severely polluted months when the PM10 concentrations even touched 500 µg/m3.

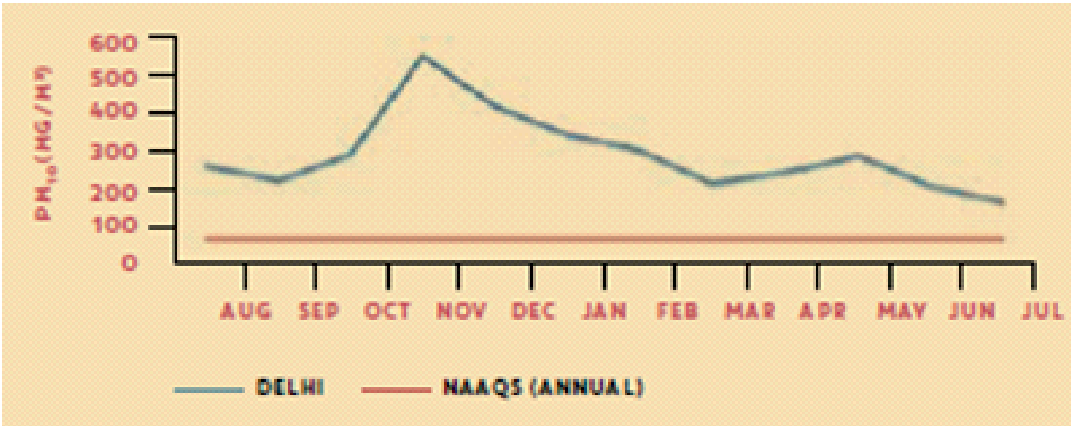


Figure 11: *PM Concentrations in Delhi in 2015 (Airpocalypse Greenpeace 2018)*

If we are considering the the NCR the Gurgaon and Faridabad also the main culprit cities for the bad air quality the report of Green Peace also showing the same (Fig . 12).

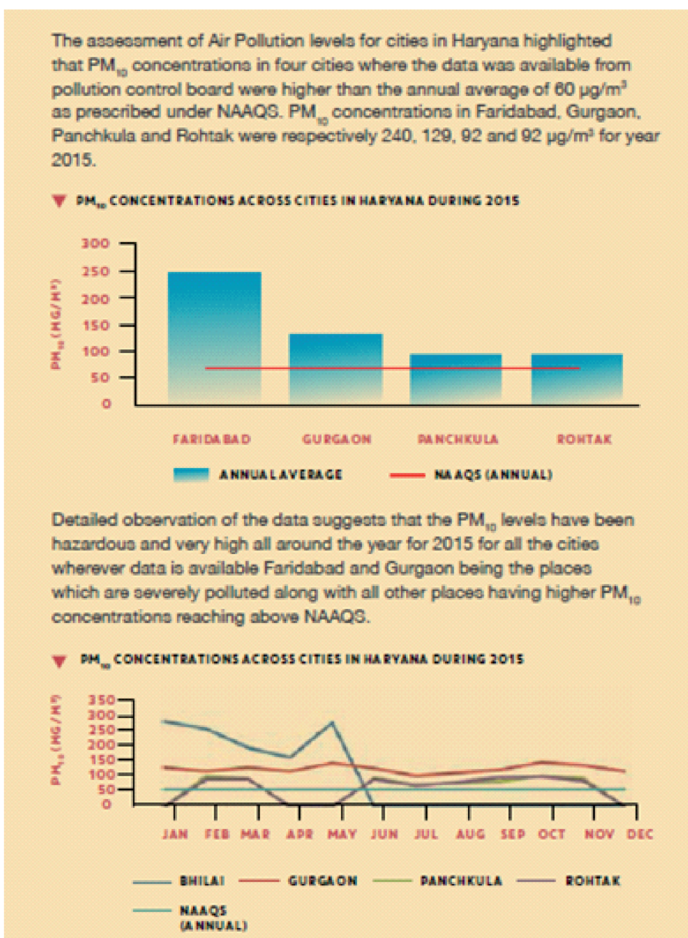


Figure 12: *Air Quality Status of Haryana (Airpocalypse Greenpeace 2018)*

6.1(a) Monitoring of Air Quality in Delhi: CPCB Studies (15)

Air quality monitoring in Delhi is carried out through a number of air quality monitoring stations

situated across the territory. The monitoring is undertaken by various organizations viz. Central Pollution Control Board (CPCB), Delhi Pollution Control Committee (DPCC), and System of Air Quality and Weather Forecasting and Research (SAFAR) of Indian Institute of Tropical Meteorology (IITM), Pune. As per the NAMP of CPCB, manual air pollution monitoring is carried out at Sarojini Nagar, Chandni Chowk, Mayapuri Industrial Area, Pritampura, Shahadra, Shahzada Bagh, Nizamuddin, Janakpuri, Siri Fort, and at ITO as traffic intersection station across the Delhi. Apart from the manual air monitoring stations, continuous ambient air quality monitoring (CAAQM) stations of CPCB are also located at 11 locations viz. Anand Vihar, Civil

Lines, DCE, Dilshad Garden, Dwarka, IGI Airport, ITO, Mandir Marg, Punjabi Bagh, R.K. Puram, and Shadipur across the city (Figure 13). DPCC has air quality monitoring stations at 6 locations viz. Civil lines, Punjabi Bagh, Mandir Marg, Anand Vihar ISBT, IGI Airport, and R.K. Puram. In addition to CPCB and DPCC, there are 8 monitoring stations of SAFAR at various locations in Delhi, as shown in figure 13, to monitor the ambient air quality on real time basis. The data obtained from these stations are also used for the determination of national air quality index.

Figure 13: AQMS across Delhi (Air Pollution in Delhi CPCP 2016)

6.1 (b) Trends of Pollution across Delhi as per CPCB Studies (15) :

Air quality for the three major pollutants (SO2, NO2, and PM) is determined to understand the trend of pollution in Delhi during recent years. On the basis of annual average concentration of pollutants, air quality trend has been seen for the years 2009 – 2015 along with the comparison with existing national ambient air quality standards (NAAQS), 2009. It can be seen in figure 14 that among the three pollutants viz. SO2, NO2, and PM10, the concentration of NO2 and PM10 are far exceeding the prescribed standard limits. The concentration of SO2 is within the standard limits. However, as far as NO2 is concerned, continuous rise in concentration was observed in past 7 years. Moreover, the problem of particulate matter (PM10) is more critical. Since 2009, approximately 258 – 335% rise has been observed in PM10 concentration compared to the standards. Although the concentration has been slightly reduced since 2011, but it is still far above the safe limits.

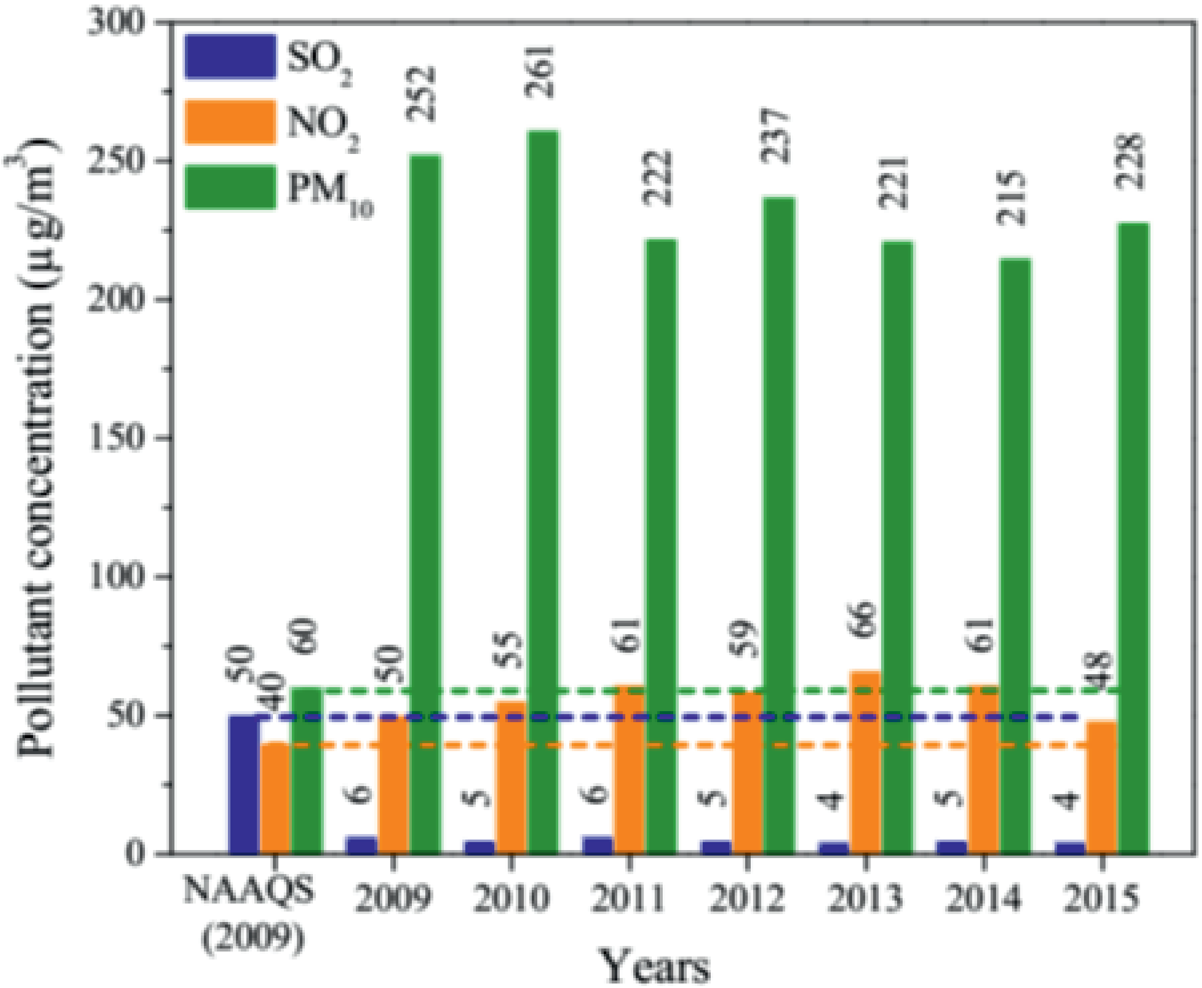


Figure 14: *Air quality trends in Delhi (2009 – 2015) based on manual air quality monitoring stations (Air Pollution in Delhi CPCP 2016)*

Apart from the annual average data, continuous air monitoring data of Delhi is also recorded by CPCB at 11 locations, as stated above. It is quite evident from the graph that concentration of NO2 and PM2.5 is very high. Among all the locations, NO2 and PM2.5 concentration is least at Dwarka. The concentration of particulate matter (PM2.5) at all the other locations needs to be curbed down urgently as the values recorded are very high. Moreover, the concentration of SO2 is acceptable at all the locations across Delhi.

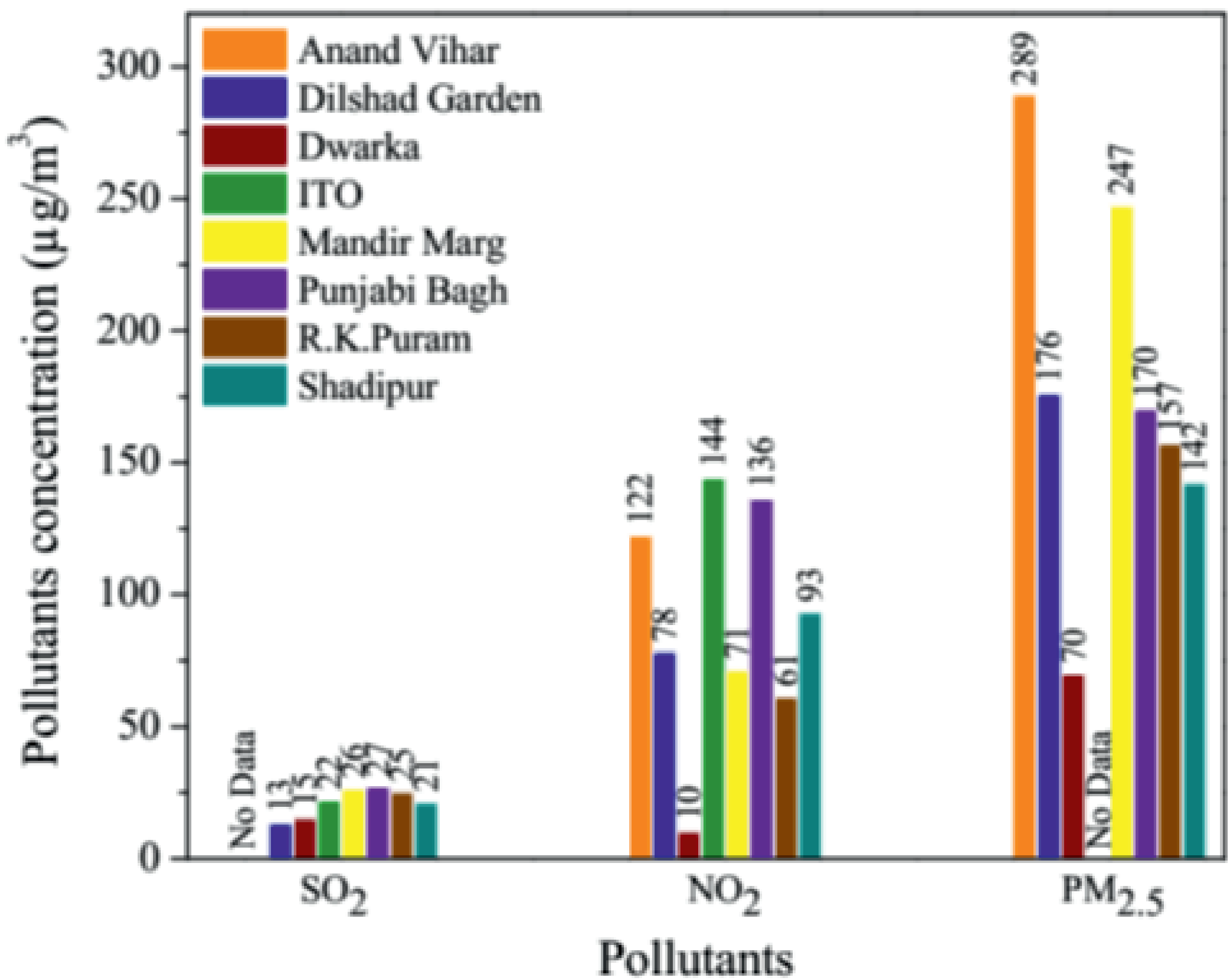


Figure 15: *Air quality trends in Delhi (Dec. 1 – 10, 2015) based on the data of continuous air quality monitoring stations (Air Pollution in Delhi CPCP 2016)*

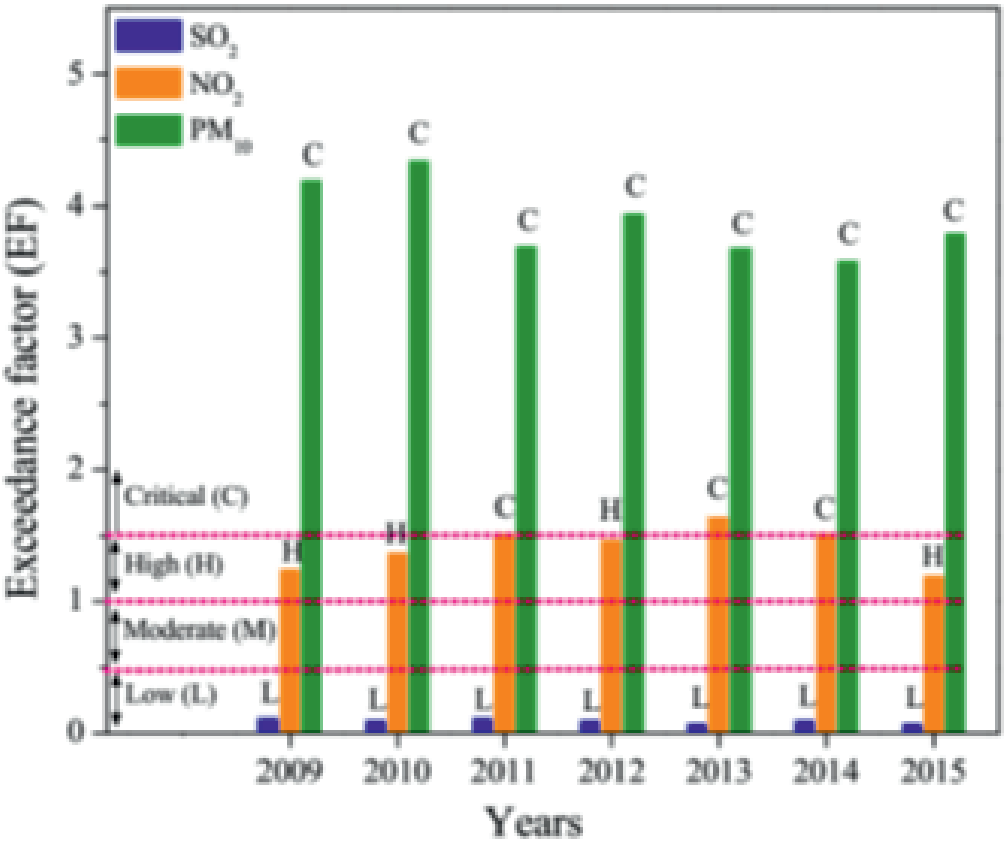


Figure 16: *Pollution level based on exceedance factor (EF) of SO2, NO2, and PM10 in Delhi (Air Pollution in Delhi CPCP 2016)*

7.0 Identification of Major Sources: Study by The Energy and Resource Institute (TERI) (16)

The Energy and Resource Institute (TERI) and Automotive Research Association of India (ARAI) did a study in 2016 to show the various major sources of PM 10 and PM 2.5. The study carried out by using two modeling-based approaches. The first approach relied upon monitoring and chemical characterization of PM2.5 and PM10 samples. The chemically speciated samples along with source profiles were fed into the receptor model to derive source contributions. In the second approach, source-wise emission inventory, along with meteorological inputs and boundary conditions were fed into a dispersion model to simulate PM10 and PM2.5 concentrations. The modeled concentrations were compared with actual observations for validation. The validated model has been used to carry out source sensitivity to derive source contributions and future projections of PM2.5 and PM10 concentrations. Finally, various interventions have been tested which can reduce the pollutant concentrations in future years.

A comprehensive exercise of air quality monitoring was carried out for a period of two seasons in one year at 20 representative locations (9 in Delhi City, 4 in Uttar Pradesh, 7 in Haryana) in the NCR including kerbside, industrial, commercial, residential, and reference sites, which has different land use pattern and sources of activity (Table 3).

Table 3: Various sites selected for Air-Quality Monitoring in NCR (Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources: Study by The Energy and Resource Institute (TERI))

Site No.	Location	Site ID
1	ITO square	ITO
2	R. K .Puram, Sector 2	RKP
3	Bahadurgrah	BHG
4	Shahdara	SHD
5	Mayurvihar, Phase 1	MYR
6	Janakpuri	JNP
7	Chandani Chowk	CHN
8	Panipat	PNP
9	Naraiana Industrial Sector	NRN
10	Wazirpur Industrial Sector	WZP
11	Rohini, Sector 6	RHN
12	Sonipat	SNP
13	Ghaziabad 1	GHZ-1
14	Ghaziabad 2	GHZ-2
15	Noida- Sector 6	NOI-1
16	Noida- Sector 1	NOI-2
17	Huda sector, Gurgaon 1	GRG-1
18	Palam Vihar, Gurgaon 2	GRG-2
19	Faridabad 1	FBD-1
20	Faridabad 2	FBD-2

All the twenty sites were distributed in Delhi-NCR based on land use type and prominent wind direction to capture air quality levels under different activity profiles.

The TERI study shows that the average concentrations of PM10 and Pm 2.5 at various sites is much higher in both summer and winter season as In summer season, average concentration of PM10 at all monitoring sites across Delhi-NCR was 188 ± 37 μg/m3. Similarly, average concentration of PM2.5 in summer season was from 131 to 263 g/m3. In winter season, maximum concentration of PM10 was 441 g/m3. Similarly in PM2.5, average concentration was 201 g/m3 varying from 92 to 254 g/m3..

7.1. Salient Observations of TERI Study:

PM10:

- Seasonal variation of PM10 shows higher contribution of dusty sources in summer (38%–42%) as compared to winter in Delhi-city as well as NCR Towns. This can be attributed to dry conditions and higher wind velocities resulting in entrainment of dust.
- However, contribution of dusty sources (e.g. road, construction and soil dust) was also significant in winter season (23%–31%). contribution of vehicles to PM10 was slightly higher in winter (17%–18%) in Delhi-city and NCR Towns than in summer (15%–16%).
- Biomass burning contribution was slightly higher in winter in Delhi-city (14%) than in summer (12%), whereas in NCR Towns the contribution was similar in both the seasons (15%–16%).
- Contribution from industrial sources was similar in both summer and winter seasons in Delhi-city (10%–12%) and NCR Towns (14%–15%). Contribution in NCR Towns was higher as compared to Delhi-city due to the presence of industries in the proximity. There are several types of industries operating in NCR Towns including bricks, sugar, paper, dyeing, rubber, chemical ceramics, iron & steel, textile, fertilizer, stone crushers, and casting & forging etc.
- Other sources, which include DG sets showed similar contribution of about 4%–5%. Contribution of secondary ions to PM10 is significantly higher in winter (23%–25%) than in summer (11%–15%) in both Delhi-city and NCR Towns.

PM2.5:

- Seasonal variation of PM2.5 shows significantly higher contribution of dusty sources in summer (31%–34%) as compared to winter (15%) in Delhi-city as well as NCR Towns. Higher contribution of dusty sources even in PM2.5 can be attributed to dry conditions and higher wind velocities in summers resulting in contribution from far-off sources. Primary contribution of vehicles to PM2.5 was higher in winter (20%–23%) in Delhi city and NCR Towns than in summer (18%–20%).
- Biomass burning contribution was significantly higher in winter in Delhi-city and NCR Towns (22%) than in summer (15%).

- Contribution from industrial sources was similar in both summer and winter seasons in Delhi city (10%–11%) and NCR Towns (13%). Contribution in NCR Towns was higher as compared to Delhi-city due to the presence of industries in the proximity.
- Other sources, which include DG sets showed contribution of less than 5%. Contribution of secondary ions to PM2.5 was higher in winter (26%) than in summer (17%–18%) in both Delhi-city and NCR Towns.

7.2 Emission Inventory

Source-wise multi-pollutants inventories of air pollutants have been prepared by TERI for the year 2016 as given in Table 4.

Table 4: Annual emission inventory of pollutants (kt/yr) in Delhi city and NCR (including Delhi) for 2016 (Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources: Study by The Energy and Resource Institute (TERI))

SECTOR	DELHI						NCR					
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	NMVOC
TRANSPORT*	12.8	12.4	126.9	1.1	501.1	342.1	68.6	66.5	528.9	4.4	1750.9	886.5
INDUSTRIES	1.3	1.1	1.6	4.6	0.2	0.0	288.3	127.4	85.2	556.2	620.0	27.0
POWER PLANTS	6.1	3.5	11.2	23.6	3.5	0.9	73.7	41.1	132.5	297.1	13.4	9.4
RESIDENTIAL	2.9	2.0	3.7	0.2	61.1	12.7	204.3	131.5	38.0	16.8	1700.3	374.1
AGRICULTURAL BURNING	0.5	0.4	0.1	0.0	2.7	0.3	174.1	102.2	30.6	9.0	781.1	209.2
ROAD DUST	24.0	5.8	0.0	0.0	0.0	0.0	137.2	30.6	0.0	0.0	0.0	0.0
CONSTRUCTION	14.2	2.7					43.7	7.8				
DG SETS	0.1	0.0	0.7	0.0	0.2	0.1	3.7	3.2	53.0	3.5	11.4	4.3
REFUSE BURNING	1.4	1.2	0.5	0.1	4.6	2.7	17.5	14.4	5.5	0.7	56.0	33.3
CREMATORIA	0.4	0.2	0.1	0.0	2.2	1.2	1.5	0.8	0.2	0.0	7.7	4.3
RESTAURANT	1.4	0.8	0.4	1.3	2.5	0.4	1.7	1.0	0.5	1.6	2.9	0.4
AIRPORT	0.1	0.1	6.6	0.5	13.6	7.0	0.1	0.1	6.6	0.5	13.6	7.0
WASTE INCINERATORS	0.5	0.3	4.1	1.6	0.9	0.0	0.5	0.3	4.1	1.6	0.9	0.0
LANDFILL FIRES	1.8	1.5	0.6	0.1	5.8	2.2	1.9	1.6	0.6	0.1	6.1	2.3
SOLVENTS						57.3						112.8
TOTAL	68	32	156	33	598	427	1017	528	886	892	4,964	1671

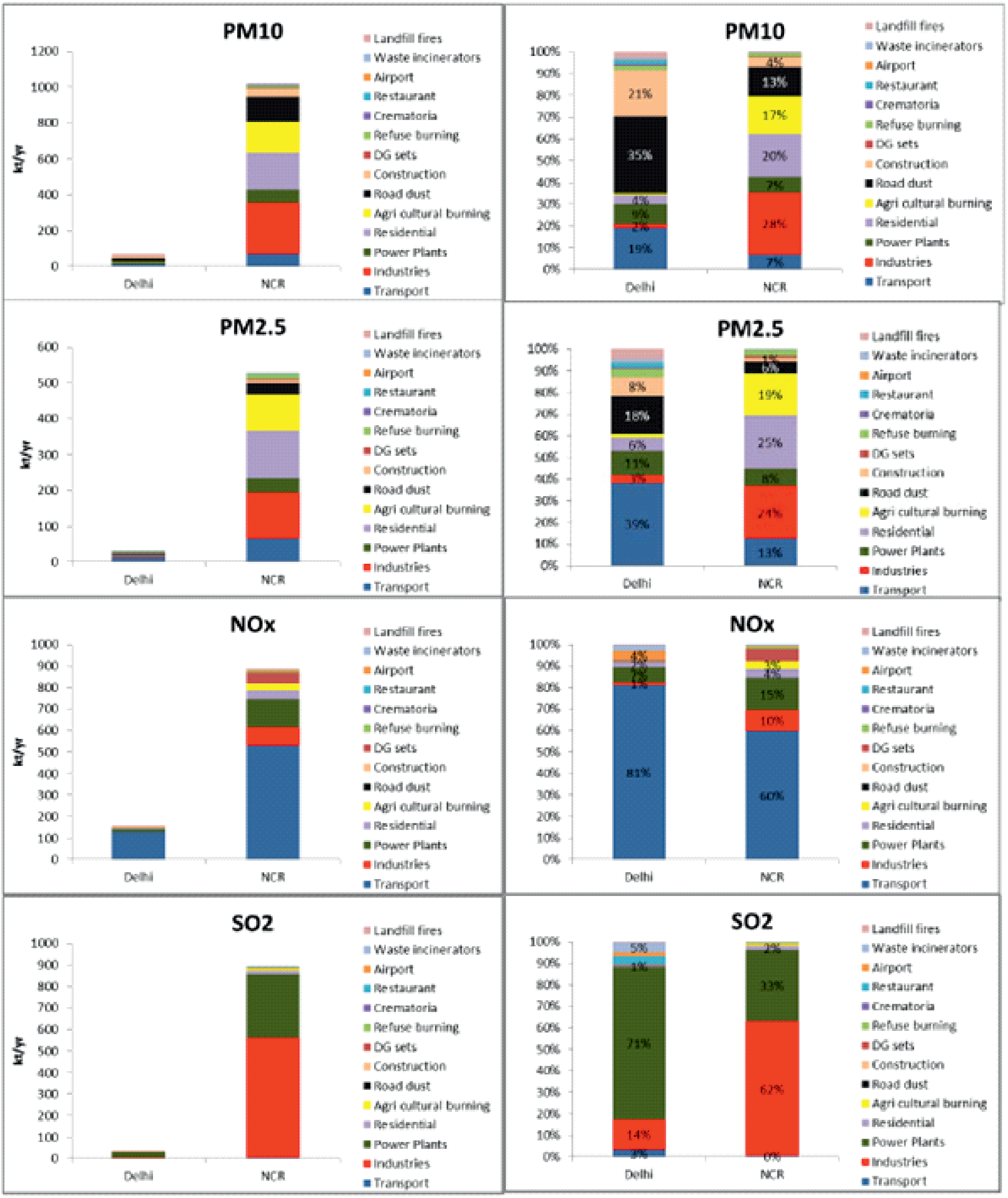


Figure 17: *Absolute and percentage share of different sectors in overall inventory in NCR (including Delhi) and Delhi city(Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources: Study by The Energy and Resource Institute (TERI))*

7.3 Geographical Contributions

This study also estimated the contribution of various regions towards PM2.5 and PM10 concentrations in Delhi and NCR Towns. ***The average contribution of Delhi's own emissions in Delhi's PM2.5 concentrations was found to be 36% in winters and 26% in summers. However, there are variations across different places in the city (Fig. 18).***

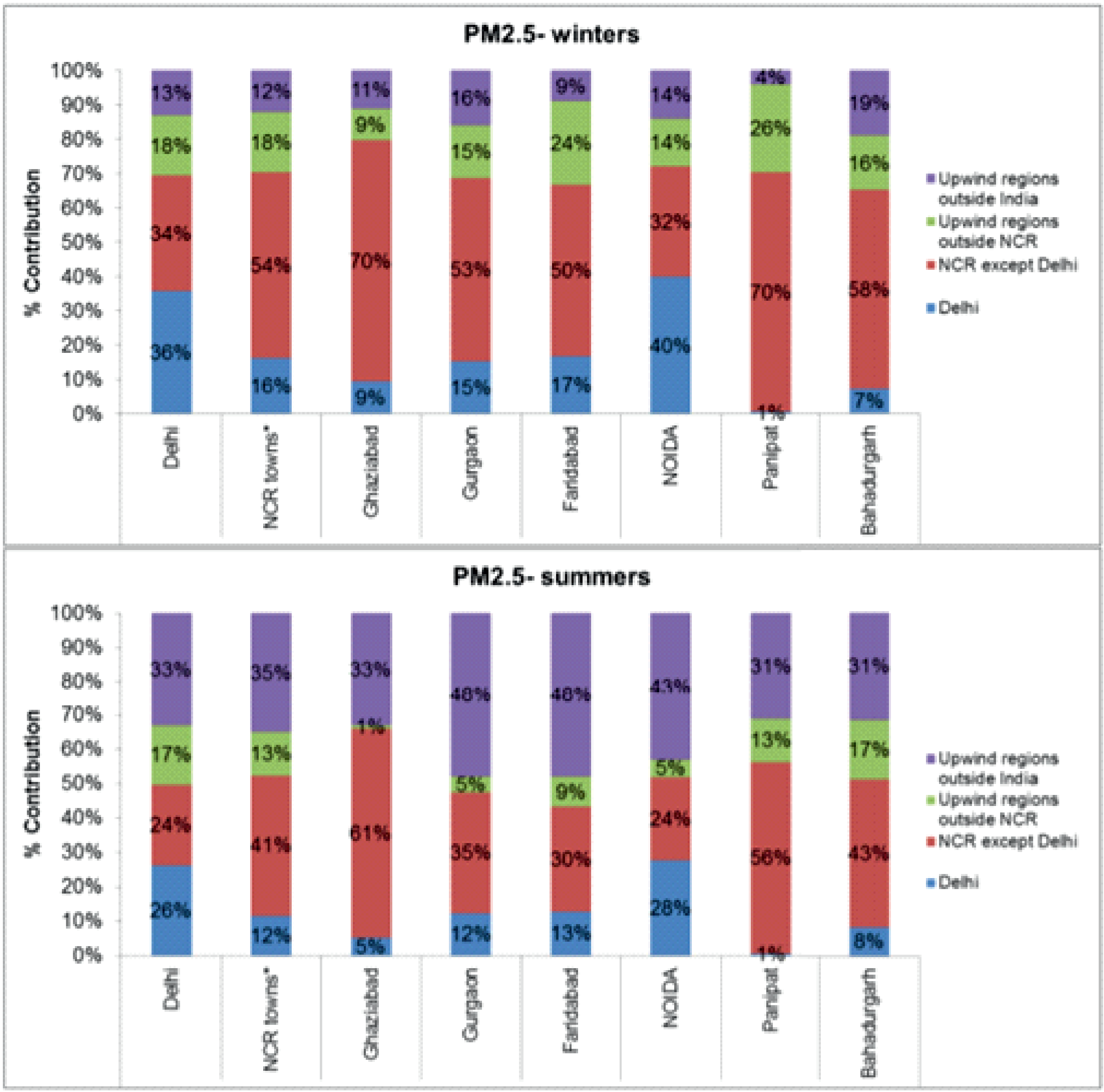


Figure 18: *Contribution of various geographical regions in PM2.5 concentrations in different towns during winter and summer seasons (Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources: Study by The Energy and Resource Institute (TERI)).*

7.4: Proposed Action Plan by TERI :

On the basis of above studies and estimated future projections TERI and ARAI proposed strategic plans for long term 2030 and for short term 2025 for concentration reduction as given below (Table 10).

Table 5: Action plans with the list of interventions selected for reduction of pollutant concentrations in Delhi-NCR (Source Apportionment of PM2.5 & PM10 of Delhi NCR for Identification of Major Sources: Study by The Energy and Resource Institute (TERI))

S.No.	Strategies	Description	Desired Time frame	Suggested implementation agencies
	Biomass Burning ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 14% and 10%, respectively.)			
1	Increase in LPG penetration in NCR by 75% in 2025- 100% in 2030	Convert 75% and 100% biomass to LPG in 2025 and 2030, respectively	100% LPG penetration by 2026	MoPNG
2	Use of agricultural residues as briquettes in power plants	Zero-open burning and use of residue briquettes in power plants	Agricultural residue to be used in power plants by 2020	MoP, MoA
	Transport ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 9% and 7%, respectively.)			
3	Public transportation system on electric vehicles; followed by private vehicles	25% and 50% electric buses in 2025 and 2030, respectively	25% and 50% electric buses in 2025 and 2030, respectively	State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)
4	Improved inspection and maintenance system	Setting up OBD/remote sensing based and advanced I&M centres. High emitter emissions go down from 25% to 10% (in 2025) and 25% to 5% in 2030	15 advanced I&M centres in NCR by 2021 and 30 by 2025. To support, existing PUCs to be upgraded for OBD-based testing.	MoRTH, State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)
5	Fleet modernization	All vehicles to be BS-VI	Fleet modernisation mechanisms along with scrappage centres by 2025	MoRTH, State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)

S.No.	Strategies	Description	Desired Time frame	Suggested implementation agencies
6	Reducing real world emissions from vehicles by congestion management	Reduce real world emissions by 50% by congestions management strategies	Introduce congestion pricing schemes in Delhi by 2019 and expand to NCR by 2021to shift from private to public modes of transportation*	MoUD and states urban development and transport departments
7	Shift of 50% cars and 2-w to shared commuter transport	Shift 50% of personal transport on shared taxis in 2025 and 2030	Promote private players to enhance shared transport modes by 2019	State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)
	Industries ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 32% and 31%, respectively.)			
8	Power plant controls with continuous monitoring	Implement stricter NO_x and SO_2 standards	Install tailpipe control devices by 2020.	Power plant companies, MoP, SPCBs, and CPCB
9	Introduction and enforcement of new SO_2 and NO_x standards	75% and 100% enforcement of SO_2/NO_x standards in industries in 2025 and 2030, respectively	Install tailpipe control devices in 75% of industries by 2021 and 100% by 2026	Industries, SPCBs, and CPCB
10	Enforcement of zig-zag brick kiln technology	75% and 100% enforcement of zig-zag brick kiln technology in 2025 and 2030, respectively	75% and 100% enforcement of zig-zag brick kiln technology in 2021 and 2026, respectively	SPCBs and CPCB
11	Strict PM control on stone crushers	Increase PM_{10} control efficiency to 80% and $PM_{2.5}$ 40% in both 2025 and 2030	Install wet dust suppression system and dry collection techniques in all stone crushers by 2021.	SPCBs and CPCB
12	Fuel switch to gas from solid fuels	50% and 100% fuel switch to gas from solid fuels in 2025 and 2030, respectively	Fuel switch to gas from solid fuels in 50% and 100% industries in 2025 and 2030, respectively	MoPNG, State Industrial departments

S.No.	Strategies	Description	Desired Time frame	Suggested implementation agencies
	Road dust and Construction ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 4% and 11%, respectively.)			
13	Vacuum cleaning of roads	Silt load reduction 25% and 50% in 2025 and 2030, respectively	Mechanized road cleaning at 25% and 50% roads in 2025 and 2030, respectively	Municipal corporations
14	Wall to wall paving of roads	Silt load reduction 25% and 50% in 2025 and 2030, respectively	Wall to wall paving of 25% and 50% roads in 2025 and 2030, respectively	PWD
15	Control of dust from construction activities	Barriers and water controls (30% and 60% control on PM emissions in 2025 and 2030, respectively)	Mandatory implementation of barriers and water controls in major construction sites by 2021 and all by 2026.	PWD, NHAI, Municipal bodies, PCBs
	Others ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 6% and 6%, respectively.)			
16	Use of refuse in WTE	Reduced emissions from refuse burning in WTE plants fitted with controls	Immediate market mechanism for collection and transportation of refuse to WTE	Municipal corporations and panchayats
17	Supply 24x7 electricity	Supply 24x7 electricity , DG set emissions to reduce to 10% and 5% in 2025 and 2030, respectively	Immediate arrangements for regulatory and tariff structure to make use of the power surplus situation and thereby ensuring 24x7 power supply	State electricity departments

7.5: Conclusions of the Study

Air pollution levels are extremely high in Delhi and NCR, especially in winters.

- **The assessment of both the scientific approaches reveals that transport, biomass burning, and industries are the three major contributors to PM2.5 concentration in Delhi NCR during winter. In summer, the contributions of dust from inside and outside of India eclipses the shares of these three major sectors in the PM2.5 concentrations, however, the contributions still remain significant.**
- The assessment for PM10 shows that other than transport, biomass burning, and industries, road dust and construction dust also contribute significantly to concentrations. Like PM2.5, during summers, the contributions of dust from outside of India reduce the shares of these local sectors in the PM10 concentrations.
- The study has quantified the contributions of different sources at present and in future time-frames (2025–2030). The PM2.5 concentrations are expected to increase by 5% in 2025 and by 8% in 2030 with respect to 2016, in a Business as Usual scenario. The PM10 concentrations are expected to increase by 16 and 23% in 2025 and 2030, respectively, in a BAU scenario. This is after accounting for growth in different sectors and also taking into account the possible enforcement of the interventions which have already been notified for control of air pollution. Discounting these planned interventions, the growth in PM2.5 concentrations could be 30% higher in 2030.
- The study analysed various interventions and estimated their possible impacts over PM2.5 and PM10 concentrations in Delhi and NCR. An alternative scenario has been developed considering the interventions which can provide maximum air quality benefits. The alternative scenario results in a reduction of 58% and 61% in PM2.5 and PM10 concentrations in 2030, with respect to the BAU scenario, and achieves the daily ambient air quality standards for PM10 and PM2.5.
- **The interventions which have identified as the ones with highest impact on PM concentrations in 2030 are:**
    - **Complete phase out of biomass use in NCR by enhanced LPG penetration in rural households**
    - **Use of agricultural residues in power plants and other industries to replace high ash coal and open burning in fields**
    - **Introduction of gaseous fuels and enforcement of new and stringent SO2/NOx/PM2.5 standards for industries using solid fuels**
    - **Strict implementation of BS-VI norms o Improvement and strengthening of inspection and maintenance system for vehicles**
    - **Fleet modernization and retro-fitment programs with control devices o Enhanced penetration of electric and hybrid vehicles**
    - **educing real world emissions by congestion management**
    - **Stricter enforcement of standards in large industries through continuous monitoring o Full enforcement of zig-zag brick technology in brick kilns**
    - **Vacuum cleaning of roads, wall to wall paving of roads**
    - **Control of dust from construction activities using enclosures, fogging machines, and barriers o Elimination of DG set usage by provision of 24x7 electricity and control by innovative tailpipe control technologies.**

8.0 New Age Technology Interventions-Air Pollution and Nanotechnology:

There are two major ways in which nanotechnology is being used to reduce air pollution: catalysts, which are currently in use and constantly being improved upon; and nano-structured membranes, which are under development.

Catalysts can be used to enable a chemical reaction (which changes one type of molecule to another) at lower temperatures or make the reaction more effective. Nanotechnology can improve the performance and cost of catalysts used to transform vapors escaping from cars or industrial plants into harmless gasses. That is because catalysts made from nanoparticles have a greater surface area to interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalyst simultaneously, which makes the catalyst more effective.

Nanostructured membranes, on the other hand, are being developed to separate carbon dioxide from industrial plant exhaust streams. The plan is to create a method that can be implemented in any power plant without expensive retrofitting.

Rapid and precise nanosensors able to detect pollutants at the molecular level may enhance the human ability to protect the sustainability of human health and the environment. Large increases in process control, ecosystem monitoring and environmental-based decision-making can occur if the available contaminant detection technology is more sensitive and less expensive. One of the desired technologies is a continuous monitoring tool that is able to provide information, especially information of pollutants in very short analysis time (19).

8.1 Nanotechnology for pollution prevention:

Prevention of pollution refers to a reduction in pollution sources and other practices that utilize raw materials, energy, utilities and other resources effectively in order to reduce or eliminate waste generation. Nanotechnology offers many innovative strategies to reduce waste production in various processes such as improving manufacturing processes, reducing hazardous chemicals, reducing greenhouse gas emissions and reducing the use of biodegradable plastics. The discussion below is just a few of many approaches that can be done to reduce environmental pollution. Nanotechnology is actively involved in this sector, both for producing advanced materials that have low pollution levels and improving production efficiency in industrial processes (e.g. nanocatalysts).

8.2 Environmentally friendly materials (environmentally compliant materials)

The application of nanotechnology is able to create an environmentally friendly substance or material, replacing widely used toxic materials. For example, liquid crystalline display (LCD) computer screens that are more energy efficient and less toxic have largely replaced the screen cathode ray tubes (CRTs) which contain many toxic materials. LCDs also do not contain lead and consume less energy compared with CRT computer screens. The use of CNTs in computer screens may further reduce the impact on the environment by eliminating toxic heavy metals, reducing material and energy needs drastically, as well as improving performance according to customer needs. The example of display technology that uses CNTs is field emission displays (FEDs).

In addition, the application of nanotechnology in composite materials has the potential to produce a material with better mechanical and other properties. This is because nanotechnology has the ability to produce structures that are lighter and smaller without degrading the quality of existing properties. The advantage of this technology is the increased robustness, reduced system costs and whole replacement, as well as reduced environmental impact. Examples of environmentally friendly materials that can be produced using nanotechnology are: biodegradable plastics made from polymers with a molecular structure that is easy to decompose; nanocrystalline composite materials that are not toxic to replace the lithium–graphite electrodes in rechargeable batteries; and glass with self-cleaning ability.

8.3 AI and IoT to combat air pollution issues:

The advances in technology give us the opportunity to reach people directly and build a more sophisticated monitoring and communication network. AI-enabled model rapidly assesses plans to cut air pollution. Researchers have developed a new computer model to help decision makers quickly assess proposed strategies to cut air pollution, by generating an array of useful data and maps in under half a minute. The model uses artificial intelligence (AI) technology to quickly make sense of the complex problem of urban air quality, and innovatively considers the influence of public opinion in its assessment of emission reduction strategies- given that some are deemed more socially acceptable than others.

We could leverage both artificial intelligence (AI) and the internet of things (IOT) with the capabilities from an increasing range of personal devices whether it be the 2.5 billion smart phones or the estimated 278 million smart watches in the world.(24) Indeed, the wearable health and fitness technology sector is set to grow 10–20% in the next five years, with an expanding set of capabilities. These devices measure elements such as heart rate, blood pressure, and breathing rate, which are indicators of overall health and are also measurable that change with exposure to air pollutants such as PM, nitrogen oxide and sulfur oxides. Yet they also monitor spatial and GPS data, which if combined could demonstrate the impact of the external environment on health factors, and better inform people of the issues.

9.0 A few Case Studies- Cina, Singapore, NY/NJ and London :

1. How China Achieved its Clean Air Goals[(2)]:

Since the initial passage of the framework Environmental Protection Law in 1979, China has passed many laws, regulations, and standards addressing environmental protection. The Law on Prevention and Control of Air Pollution, the primary law dealing with air pollution, provides comprehensive measures on air pollution prevention and control.

Construction of new industrial facilities that may affect the atmospheric environment must be preceded by environmental impact assessments, and standards for the emission of atmospheric pollutants and the total emission control requirements for key atmospheric pollutants must be met. Polluting entities must also obtain a pollutant discharge permit for industrial emissions or the emission of specified hazardous and toxic atmospheric pollutants. Effective January 1, 2018, a newly designed environmental protection tax replaced the pollution discharge fee. The tax applies to specified air pollutants, not including carbon dioxide.

Pollutants discharged by motor vehicles and vessels as well as non-road mobile machinery must not exceed the stipulated emission standards. China has been implementing vehicle emissions standards that mainly follow the EU standards. The China 5 standard for light-duty vehicles is similar to the Euro 5 standard with some deviations.

National standards for fuel consumption limits have been established for various types of vehicles. The current Phase IV standards for passenger cars, which took effect on January 1, 2016, set a fleet average target of 5.0 L/100km for new vehicles sold in 2020.

China has created a New Energy Vehicle (NEV) credit system under which passenger car manufacturers will be required to earn NEV credits starting in 2019. The excess NEV credits, if any, may be used to offset an automaker's negative corporate average fuel consumption (CAFC) points that occurred by exceeding the CAFC target set by the state.

Air pollution and carbon emissions in China have mainly been attributable to coal burning and industrial production during the early stage of economic development. In urban areas, especially megacities such as Beijing and Shanghai, emissions from vehicles have become an increasing problem (25).

In recent years, it has been observed that the emissions of long-regulated sulfur dioxide (SO2) and total suspended particulates (TSP, including particulate matter [PM10]), have passed their peak and are diminishing. The situation of fine particulate matter (PM2.5) and ground-level ozone (O3) concentration, however, is worsening. Regional air pollution problems are becoming significant. Sometimes vast regions, such as all of eastern and central China, are under very high concentrations of PM2.5 and O3 (26).

A. China's Air Pollution Prevention and Control Action Plan (27)

The administration illustrated its strong will to improve air quality in its first year, during which the State Council issued the Air Pollution Prevention and Control Action Plan in September 2013. The Action Plan provides guidance for national efforts to control air pollution in the present and near future.

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- By 2017, the urban concentration of PM10 must decrease by 10% compared with 2012, and as a result the annual number of days with fairly good air quality should gradually increase.
- Concentrations of PM2.5 in the heavily polluted Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta regions must fall by around 25%, 20%, and 15%, respectively.
- PM2.5 annual concentrations in Beijing must be controlled below 60 micrograms per cubic meter.

B. China's 13th Five Year Plan (28)

China's 13th Five-Year (2016–2020) Plan for Economic and Social Development contains strong commitments to improve air quality and control emissions. The Plan describes the country's clean-air action plan as follows:

Air quality standards in cities are met, strictly enforce obligatory targets, see that cities at and above the prefectural level achieve a 25% reduction in the number of days of heavy air pollution, and channel greater effort into reducing fine particulate matter emissions in key regions. They establish a monitoring system to ensure that environmental protection standards for vehicles, watercraft, and fuel oil are achieved.

During the past four decades, China has adopted many laws, regulations, and standards addressing environmental protection. Implementation of the environmental protection laws used to be weak, but has becoming increasingly stronger over the past few decades when the severe air pollution has caused huge health damages and social losses. Air Quality Standards, Control of Coal Use, Vehicle Emissions Standards, Fuel Efficiency, CAFC and New Energy Vehicle Credits all have done great good to China.The recent good news is that Beijing is now out of top 200 worst polluted cities of the word. Great goal of making the capital city of the world's developed and most populous country now is able to provide its inhabitants air quality that has PM2.5 at 42.6 µg/m3.

2.Singapore Case Study: Cleaning Air Pollution in a Generation (4)

Today, Singapore's air quality standards meet those of the US Environmental Protection Agency (USEPA), and the emission standards are within those of the World Health Organization. That Singapore's clean air has been achieved over a generation - dating from the 1960s in tandem with its rigorous industrialization and urbanization programs, after it achieved self government in 1959 and went on to gain independence on 9 August 1965 (after it separated from Malaysia) - is worthy of a case study.

Apart from local sources of pollutants, Singapore has had in more recent times to deal with the trans-boundary haze pollution from Indonesia; Singapore has also to cooperate with international efforts in addressing global concerns relating to the depletion of the ozone layer through greenhouse gases and global warming due to climate change. Singapore is today a sophisticated urban, industrialized city state. It has a total land area of some 682.3 sq km, and a population which grew from about 1.64 million in 1960 to over 4.13 million today with the resident population growth of 1.7% (2000 -2001).

After separation from Malaysia in 1965, Singapore had to embark unrelentlessly on an industrialization and urbanization process, both for economic and political survival, and at the same time work towards giving its citizens a "quality of life".

2.1 A Generation of Clean Air in the 'Making': An Integrated, Comprehensive Approach

Singapore's success story begins with the political will to curb air pollution at the beginning of Singapore's development cycle. The industrialization and urbanization in the 1960s, conceived Singapore as a clean and green city. Perhaps no other Prime Minister in the world had initiated a tree planting campaign as the then Prime Minister did in 1963 - he foresaw that trees played an important role in the development process, including cleaning the air.

But for the early vision, Singapore would have been turned into a bleak, blighted, smoky and polluted city as some of the industrialized, urban cities are in the world today. It may be observed that while much of its natural fauna were bulldozed to make way for development, it was subsequently substituted with cultivated greenery to make it a Garden City. Today, the Garden City serves as a carbon sink to reduce carbon dioxide. Indeed, one of the recommendations in the Draft Singapore Green Plan 2012 on "Clean Air " is "to require industries to plant trees to mitigate their CO2 emissions.

Singapore focus on the Clean Air: From "Visions" to Missions and Implementations Strategic, Land use Planning - Sitting of Industries, Clean Air Plans, Programs, Guidelines, Initiatives and Code of Practice on Pollution Control, Clean Air Laws Relating to Local, Regional and Global Atmosphere,

Local: industrial and vehicular air pollution in Singapore

Regional: Transboundary "Haze" Pollution In more recent years Singapore has been faced with not only pollution associated with its industrialization and urbanization process but also regional (eg Indonesian fires) and global pollutants - greenhouse gases, ozone depletion, and chlorofluorocarbons. Such pollutants know no boundaries and Singapore has adopted/ ratified regional and international agreements relating to clean air. Such international pollutants like greenhouse gases (carbon dioxide, nitrous oxide, methane, chlorofluorocarbons) sulphur dioxides are also produced by industrialization and vehicular pollutants in Singapore.

The Indonesian forest fires have been occurring in the 1980s but it was only in the second half of the1990s that they have become very serious and those in 1997 and 1998 were disastrous, spilling into its neighboring countries such as Malaysia, Singapore, Philippines and even Thailand. It is estimated that the 1997 fires caused Singapore and Malaysia some US $1.4 billion in increased health care and lost in the tourist industry.

During the haze period, Singapore's PSI fell below the healthy level. Then Indonesian haze has led the ASEAN member countries to draft the recent ASEAN Agreement on Transboundary Haze Pollution which was adopted by the ASEAN member states on 10 June 2002 in Kuala Lumpur. This Agreement gives effect to the 1997 Regional Haze Action Plan and the ASEAN Cooperation Plan of Action on Transboundary 1995.

Since 1996 Singapore banned the import of HBFCs. Measures to phase out ozone-depleting substances started in 5 October 1989 with the implementation of the quota allocation system for Chlorofluorocarbons.

A prohibition was imposed for the import and manufacture of non pharmaceutical aerosol products and polystyrene sheets /products. Industries are encouraged to replace HCFCs with non- ozone -depleting substitutes and technologies whenever possible.

In 2000 the EPC (Ozone Depleting Substances) Regulations was passed and came into effect on 1st January 2000, implementing the Montreal Amendment and Copenhagen Protocol. In 1996 Singapore banned the import of CFCs and also the import of HBFCs. The Ministry of Trade and Industry, through the Trade Development Board, administers a Tender and Quota Allocation System to cap the consumption of ODS in accordance with guidelines set by the Protocol. The system ensures equitable distribution of the controlled supply of ODS to registered distributors and end-users.

Singapore has been vigilant over the whole generation of its development to keep pollution at bay. It began with a clear and vision in 1968 which was upgraded in 1990 and then to a projection to 2012. So far, Singapore has attempted to work closely to realize these visions. It had been constantly reviewed its strategies, policies and has had a core of priorities - all these including updating its laws, exploring innovative techniques, and adopting a holistic approach to air management. In its latest Singapore Green Plan 2012, it has proposed a number of initiatives which aim at realizing its vision of "a global city with an environment comparable to the best in the world." This includes clean air up to world standards.

2.2 Quality Living Environment Clean Air

- Government to develop innovative ways to manage industries more effectively through judicious use of regulations and incentives that: – promote R&D in environmental technology – encourage innovative ways to limit emissions e.g. by transforming air pollutants into useful marketable products – encourage industry to set up and certify environmental management systems to ISO 14001 through 'green' government procurement practices and positive discrimination on enforcement routines, government setting example by requiring all government linked agencies to be ISO 14001 certified – formulate a scheme to assist SMEs obtain ISO 14001 certification – encourage the use of cleaner energy, e.g. solar energy e.g. by providing financial incentives – require industries to plant trees or undertake measures to mitigate their CO_2 emissions
- Require more stringent maintenance standards and enforce laws that do not allow drivers to keep their engines running when waiting for passengers
- Develop a holistic energy-environment management strategy to make it possible to harness cleaner energy sources (such as solar and wind energy) for mass use and achieve energy efficiency at reasonable cost. – Create market demand and keep costs affordable through appropriate incentives and financial assistance – Develop R&D capability to bring technology to the market – Change the rules to encourage energy efficient practices such as co-generation – Formalize a mechanism for close co-ordination among government agencies
- Continue to look for new emerging technologies in areas like renewable energy and provide test bed facilities for these technologies. The strategy should encourage – use of cleaner fuels and renewable energies – more efficient electricity generation – waste heat recovery and use
- Import electricity (either from foreign companies or local companies set up outside Singapore) – Look into implementation of an ASEAN power grid to enable Singapore to import electricity produced by cleaner energy sources such as hydro-power, natural gas, etc.
- Create consumer demand for energy efficiency – Educate consumers on energy conservation at home, including labelling of electrical appliances – Promote use of energy efficient devices, appliances and services – Government to set the lead by procuring from energy efficient/environment friendly – efficient companies
- Specific measures for tourism industry: – Raise awareness of energy conservation amongst tourists at point of entry (airport/port) – Require service apartment occupants to be separately metered and charged for energy use – Encourage deployment of intelligent building features at tourist facilities such as hotels, buildings, etc through the use of financial incentives
- Measures for building industry: – Set energy efficiency benchmark and continually improve it for all developments. Ensure energy conservation features are incorporated in building design code – Provide financial incentives to promote greater use of energy efficient technology such as district cooling systems – Promote architectural designs that reduce energy requirements (e.g. natural ventilation, low energy lighting and efficient air-conditioning) – Extend the Overall Thermal Transfer value to industrial buildings and residential dwellings – Ensure the installation of optimal size air-conditioning units by introducing standards – Set up a research centre in

the university to conduct R&D on the architectural designs that reduces energy requirement (e.g. natural ventilation, low energy lighting and efficient air-conditioning)

- On transport: – Make public transport alternatives available, convenient and affordable (e.g. don't deny people access to buses when LRT is widely implemented) – Encourage cycling as an alternative mode of transport through the use of designated cycling tracks and park connectors – Make access to facilities convenient to pedestrians (spoil them with choices, even if it is at the expense of cars)

3. Case Study New Jersey (2) :

Changes in Air Pollution in New Jersey Air pollution in New Jersey, prior to suburban sprawl, was dominated by pollutants emitted from industrial sources, energy production, and space heating. These air pollutants included SO2, soot, total suspended particles (TSP), carbon monoxide (CO), and volatile organic compounds (VOCs). Many of the same pollutants caused acute healthrelated air pollution episodes (e.g., the London Smog, Donora, PA) and persistent air pollution. Stern (1957) summarized national TSP measurements from 1953 to 1957 using U.S. National Air Sampling Network data. In urban areas TSP was high, with a mean of about 140 µg/m3, and the 95th percentile for all the data was > 370 µg/m3 (Stern 1957).

New Jersey was within this distribution of high levels of TSP. Annual reporting of New Jersey air pollution began in the 1960s and, with the formation of the U.S. EPA, measurements expanded in both quantity and quality. During the 1950s, one of the main approaches used to identify point source air pollution was a simple Ringelmann Chart of "blackness" of emissions (Stern 1962).

One of the first long term air pollution records for New Jersey is that of the indicator of black smoke called coefficient of haze (COH) (NJDEP 2011). From 1967 to 2007, there was a 10× reduction in the annual COH values, indicating major decreases in uncontrolled combustion source emissions, elimination of residential coal burning, and reduction of sulfur in oil (Vallero 2008). In fact, the largest percentage reduction in COH occurred before the implementation of the 1970 CAA (NJDEP 2011).

As in New York City, New York, and Pittsburgh, Pennsylvania, attempts to control air pollution in New Jersey started prior to the formation of the U.S. EPA in 1970 (Beck 2007). For instance, Hudson County implemented a smoke control act in 1931 (Woodward 1955). The approaches considered for addressing problems ranged from the rational to the ridiculous (Mallette 1957a, 1957b).

As an example of the latter, in one New Jersey county a proposal was implemented to mask hydrogen sulfideodors (rotten egg–like) emitted by a chemical plant by using a 400℠lb drum that released a deodorizer at times of high odor (Mallette 1957c). In 1954, New Jersey adopted one of the first statewide air pollution laws, the Air Pollution Control Act (State of New Jersey 1954), which established an Air Pollution Control Commission and defined the relationships between state and local pollution control organizations.

The New Jersey act required control strategies for open burning (code effective May 1956), incineration, and coal combustion (NJDEP 2000, 2002, 2006). Significant amendments to the New Jersey 1954 Air Pollution Control Act were passed in 1967, and these regulations have continued to strengthen over subsequent decades. These regulations gave the state the ability to set ambient standards, form a cabinet agency to regulate pollutants, set new source performance standards, and control sulfur content in fuels (Reitze 1999; Salmore and Salmore 2008; State of New Jersey 1954).

The 1970 Clean Air Act (CAA) gave the newly formed U.S. EPA the primary role in developing National Ambient Air Quality Standards (NAAQS) and implementing national emission regulations and control strategies (U.S. EPA 2010a). A review article by Bachmann (2007) provides an excellent summary of the problems and progress made in implementing the CAA and the influence of amendments passed by Congress in 1977 and 1990.

The New Jersey legislature created the NJDEP on 22 April 1970, coinciding with America's first official Earth Day, and adopted over 200 environment-related measures between 1970 and 1975. Changes to administrative codes established ambient air quality standards; control and prohibition of particle and gas emissions; control of smoke; permitting of facilities; prevention of toxic air pollution, landfill emissions, automobile vapor and combustion emissions, and truck and shipping emissions; reductions in chemical storage facilities; and so on.

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The clear downward trend in annual maximum concentrations of criteria air pollutants measured at all sites in New Jersey from 1965 to 2009, reported as the percentage of each pollutant's levels above or below a corresponding NAAQS, is shown in Figure 2. During the 1960s and 1970s, levels of all measured pollutants were very high, but they began to decline after the 1967 revisions to the New Jersey air pollution code. These revisions took place after the 1966 Thanksgiving New York City SO2 and PM episode, which was estimated to have shortened the lives of 366 people in New York City (Schimmel 1978).

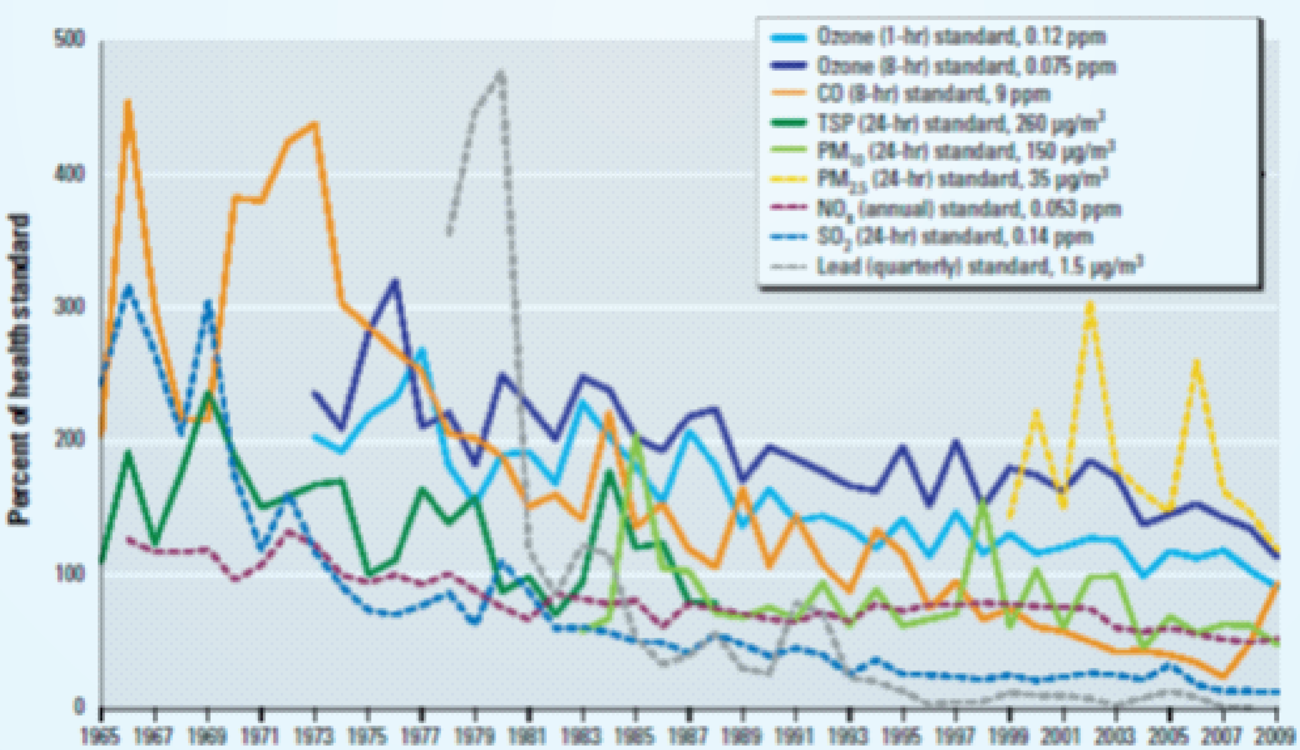

Figure 19: *Overall trend for all the criteria air pollutants in New Jersey, 1965–2009, for the annual maximum measured at all monitoring sites in the state shown as a percentage of a pollutant's level above or below the NAAQS. Historical New Jersey air monitoring data prior to 1975 was received from C. Pietarinen (personal communication) and other data from Air Data (U.S. EPA 2011).*

Measured air pollutants has expanded to include toxic substances such as benzene, which is released from both the automobile (fuel and exhaust) and industrial/commercial sources (solvent or raw material) (Vallero 2008), and formaldehyde, which is emitted directly from industrial and combustion sources and is produced indirectly through ambient formation in summertime photochemical smog.

Consistent with the implementation of new pollution controls, changes in motor vehicle fuel type and quality, and changes in chemical processes, the levels of each pollutant have decreased between approximately 4× for benzene and approximately 10× for formaldehyde over the past 15–20 years (Figure 3) (NJDEP 2011). However, the levels for each are still substantially above the 1 in 1-million excess cancer risk benchmark (Caldwell et al. 1998), which means that reductions of emissions are still needed in the future.

In addition, although reductions of air toxics emissions are focused on processes and sources that affect ambient air, many pollutants, including benzene and formaldehyde, are also emitted or produced from indoor sources. Therefore, future air toxics controls or prevention strategies (e.g., product replacement) may need to account for indoor sources of pollutants as well (Lioy 2010).

Impact of regulations and strategies:

Tracking annual maximum pollutant concentrations from the levels observed at all New Jersey monitoring sites relative to historical NAAQS standards (Figure 2) is just one of many possible ways of reporting air quality trends, but this approach provides strong evidence in support of the overall success of state and federal policies in reducing air pollution in New Jersey. In all cases, ambient pollution levels have been reduced to the point where they have either achieved the original NAAQS or they approach current standards.

This progress has meant that the vast majority of the public is now protected within a margin of safety from the deleterious effects of criteria pollutants. The changes to the NAAQS for ozone, lead, and PM (now PM2.5) have focused attention on small but highly vulnerable subgroups of the population (Bachmann 2007) based on new evidence about health effects in high-risk groups. Therefore, although the air has not been degrading at any location in the state, the targets have become tighter and require further pollution reduction strategies and monitoring, particularly in areas where there are populations at risk. Nonetheless, after > 50 years, New Jersey has made great strides in reducing air pollution levels experienced by the population as a whole.

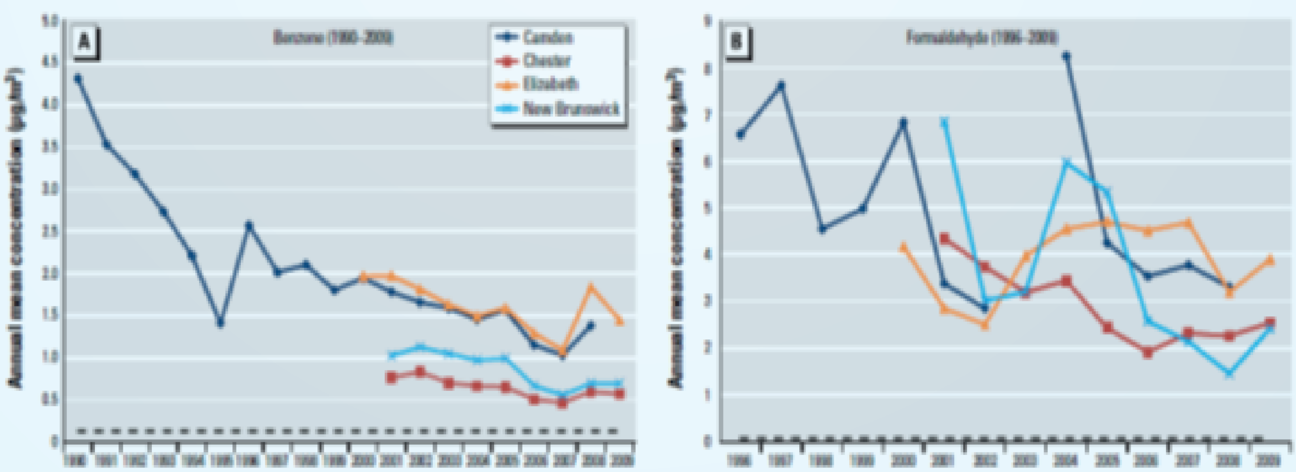

Figure 20: *Monitored concentrations of benzene (1990–2009; A) and formaldehyde (1996–2009; B) in four New Jersey cities. Levels of both pollutants have generally decreased over the past several years (NJDEP 2011).*

Challenges Ahead

All the original NAAQS have been attained in New Jersey, and the recently revised NAAQS for ozone and PM2.5 are close to being achieved. Future air pollution reduction strategies will also need to consider a) populations at risk because of biologically based susceptibility, age, and so on; b) fuels used for energy production; c) indoor air pollution; and d) consumer and personal products with the same pollutants as outdoor air.

4. London-Air Quality Strategy 2019(3):

The City of London, also known as the Square Mile, is the historic heart of London. It is home to approximately 7,500 permanent residents and 24,000 businesses. There is a working population of over 510,000 people. This is projected to increase to 640,000 by 2036. In addition to workers and residents, each year the City of London welcomes over 10 million tourists, along-side people who visit for business.

Air Quality Strategy 2019 – 24: Delivering healthy air in the City of London

Our definition of healthy air:
Concentrations of nitrogen dioxide (NO_2), small and fine particles (PM_{10} and $PM_{2.5}$) that meet health-based Limit Values and World Health Organisation (WHO) Guidelines.

Why us:
The City of London Corporation has a statutory obligation to take a wide range of action to improve air quality and protect public health. Improving air quality and ensuring good health and wellbeing is a key organisational priority outlined in our Corporate Plan (CP) for 2018-23, through which we aim to contribute to a flourishing society, support a thriving economy and shape outstanding environments.

Who we will work with:
Residents, workers, schools, businesses, Barts Health NHS, Greater London Authority, Transport for London, London Councils, London Boroughs, Government, Environment Agency, London's Universities, Third Sector, Port of London Authority, Cross River Partnership

Our Vision
The Square Mile has air that is healthy to breathe.

Our Aim
For nitrogen dioxide to meet health-based Limit Values and WHO Guidelines in over 90% of the Square Mile by 2025 and achieve WHO Guidelines for PM_{10} and $PM_{2.5}$ in the shortest possible time

Our Outcomes

The Square Mile has clean air	People enjoy good health through reduced exposure to poor air quality	We are a leader for air quality policy and action and inspire collaboration across London
Links to CP Outcome 11	Links to CP Outcome 2	Links to CP Outcome 11
Our Activities		
• Reduce emissions of air pollutants from our fleet, buildings and through our contracts • Ensure new developments, transport and public realm schemes and proposals have a positive impact on local air quality • Pilot innovative measures	• Provide robust and reliable information and data • Make use of public health networks to disseminate information • Develop tailored action plans for City of London schools • Further develop the free smartphone App CityAir	• Develop a Private Members Bill to improve air quality • Work closely with a wide range of stakeholders on air quality policy • Facilitate collaboration across London's air quality community

Demonstrating success
A measure of success for the strategy will be consistent compliance with health-based air quality limits and guidelines measured using a network of robust air quality monitoring equipment. Over the next five years, we will also continue to be recognised as a leading and highly regarded authority in the field of air quality.

Like much of central London, the City of London can experience high levels of air pollution. The pollutants of current concern are nitrogen dioxide (NO2), a colourless and odourless gas that is a product of fuel combustion, and small particles, of which there are a wide range of sources, including combustion. These particles are referred to as PM10 (small particles) and PM2.5 (fine particles). These are particles below 10 and 2.5 micrometres in diameter respectively.

The City of London Corporation (City Corporation) is required by statute to measure air pollution and develop and implement an improvement plan if health-based air quality limits are not met. Following detailed air quality monitoring, the whole of the Square Mile was declared an Air Quality Management Area (AQMA) in January 2001 for nitrogen dioxide and small particles (PM10). This was due to levels of these pollutants being higher than the required limits.

The City Corporation has had an air quality action plan in place since 2002. In 2011, the action plan was incorporated into an Air Quality Strategy outlining steps that would be taken to both improve local air quality and reduce the impact of air pollution on public health. The strategy was updated in 2015, detailing further measures that would be taken through to 20201. This strategy builds upon previous action and details measures that will be taken to 2024. Despite the implementation of a wide range of action by the City Corporation to improve air quality, the health-based limits for nitrogen dioxide are still not met everywhere in the Square Mile. Extensive monitoring, however, demonstrates that levels of nitrogen dioxide are reducing year on year, particularly away from busy roads.

The limits set in European Directives for small particles (PM10 and PM2.5) are generally met everywhere in the City of London. The only exception is adjacent to the busiest roadsides in unfavourable weather conditions. The World Health Organisation (WHO) has set its own Guidelines for concentrations of PM10 and PM2.5. These are tighter than the limits set in European Directives. Fine particulate pollution has health impacts even at very low concentrations. No threshold has been identified below which no damage to health is observed. Therefore, the WHO Guidelines aim to achieve the lowest concentrations of particulate matter possible. Reducing levels of air pollution to meet the tighter WHO Guidelines will therefore continue to improve health outcomes.

The aims of this Strategy are to ensure that:

- The City Corporation fulfils its statutory obligations for London Local Air Quality Management and improving public health
- Tir quality in over 90% of the Square Mile meets the health-based Limit Values and World Health Organisation Guidelines for nitrogen dioxide by the beginning of 2025 • through coordinated action, World Health Organisation Guidelines for particulate matter (PM10 and PM2.5) will be achieved in the shortest possible time

These aims will deliver three main outcomes:

- The Square Mile has clean air
- People enjoy good health through reduced exposure to poor air quality
- The City Corporation is a leader for air quality policy and action and inspires collaboration across London. The outcomes will be met by a range of actions as below.

10.0 India's National Clean air Program, NCAP 2019 (7):

The NCAP 2019 goes on to state that India is committed to create a clean environment and pollution free air and water. In fact, it is mandated in our constitution. India's commitments and obligations to environmental conservation and protection within the ambit of the targeted goals on environmental sustainability under the Sustainable Development Goals (SDGs) is manifested in the fact that several administrative and regulatory measures, including a separate statute on air and water pollution are under implementation since long.

The Air (Prevention and Control of Pollution) Act, 1981, was enacted under Art. 253 of the Constitution to implement the decisions taken at the United Nations Conference on Human Environment held at Stockholm in June 1972, in which India participated. Sustainable development, in terms of enhancement of human well- being, is an integral part of India's development philosophy.

However, a vast country and an emerging economy like India, faces enormous challenges with its burgeoning population and widespread poverty, in meeting its various other significant commitments associated with poverty, and eradication of hunger under the SDGs.

Air pollution has increasingly become a serious concern, predominantly because of its health impacts. Air pollution emission issues are associated with many sectors, which inter-alia include power, transport, industry, residential, construction, and agriculture. Burning fossil fuels causes air pollution that both contributes to global climate change and also contributes to air pollution. Global climate change is caused by the overabundance of greenhouse gas (GHG) emissions in the atmosphere.

The local air quality generally refers to the level of pollutants in the air that we breathe, which is typically found in the lowest part of the atmosphere, and the air quality is reduced by excess concentration of specific pollutants, namely, PM10, PM2.5, NOx , SOx , CO, etc.

The sectors in which fuel combustion contributes to GHG emissions, such as energy, buildings, industry, and transport, are the ones with the most significant air quality co-benefits and the most substantial quantitative literature. In energy and industry, the largest co-benefits come from replacing coal combustion with less polluting fossil fuels, from replacing fossil fuels with renewable energy, from improving energy efficiency, and from improving the characteristics of coal via coal washing and briquetting.

For buildings, the largest air quality co-benefits are typically linked to improvements in energy efficiency and modifications in cooking stoves. Transport studies typically aggregate the effects from a collection of interventions, including greater use of public transport and improving vehicle fuel efficiency, but transport-related studies also often aggregate effects on health outcomes from other non-pollution effects such as benefits from increased walking and cycling.

The impact of air pollution is not limited to health but extends to agriculture and the general well-being of humans, floral and faunal population. Furthermore, since air pollution is not a localized phenomenon, the effect is felt in cities and towns far away from the source, thus creating the need for regional-level initiatives through inter-state and inter-city coordination in addition to multisectoral synchronization.

While the problem of air pollution is mainly urban centric, studies show the regional scale pollution, is more concentrated in the Indo-Gangetic plains and more industrialized states. Incidences of episodic air pollution during the winters in Delhi NCR in the recent years have attracted significant media attention, thus bringing the entire issue of air pollution under regular public scrutiny.

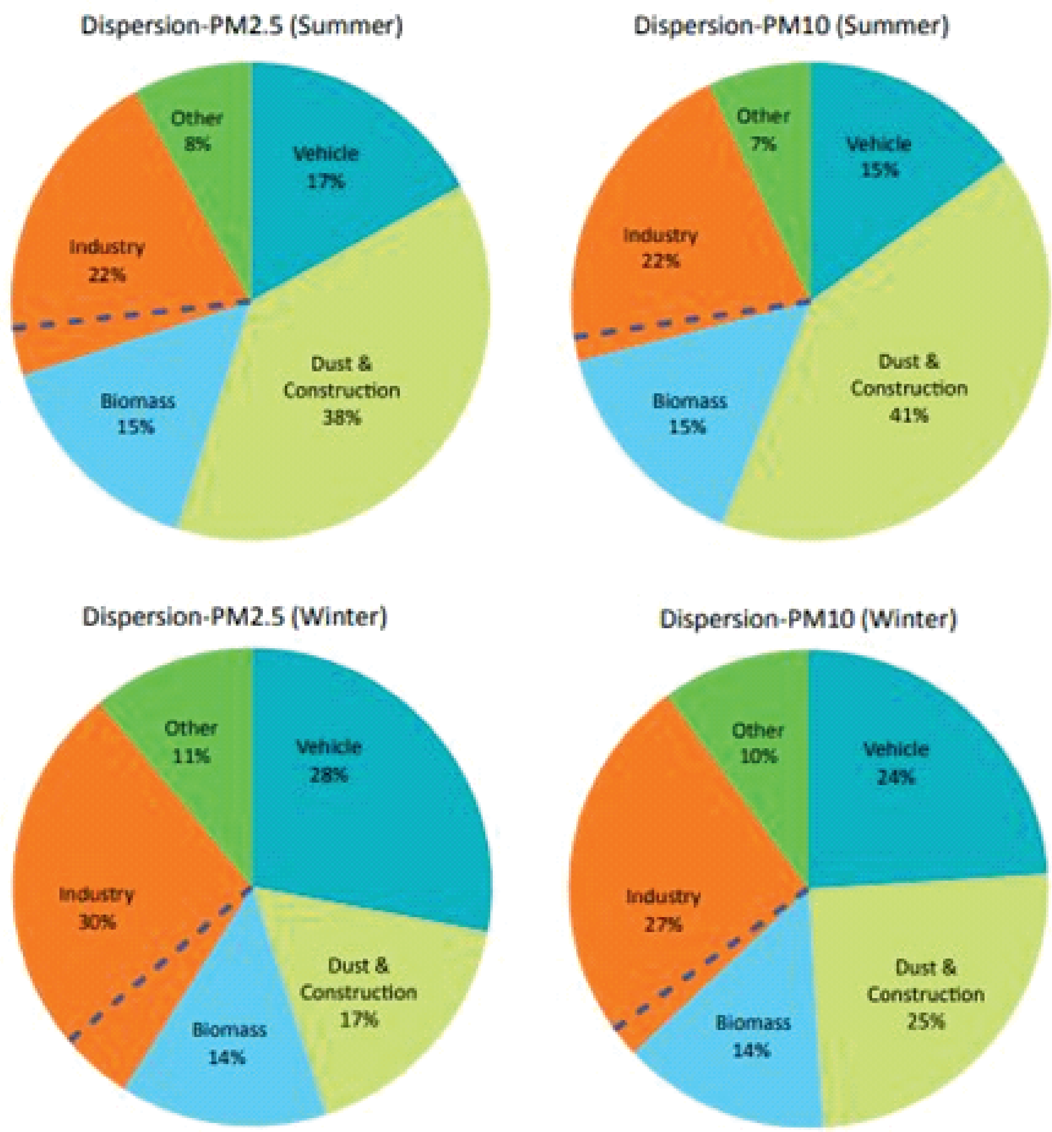

Figure 21: *Source Contributions in PM2.5 and PM10 Concentrations in Delhi (Teri-Arai Source Apportionment Study)*

10.1 MITIGATION ACTIONS AS PER NCAP 2019:

10.1.1 Stringent Enforcement through three tier mechanism for review of monitoring, assessment and inspection:

- Web-based system on the above-mentioned lines to be evolved in association with the NIC and other relevant national and international agencies.
- Adequate manpower will be made available for strengthening, monitoring, and inspection.
- Intensive training of all the stakeholders involved in implementation of this web based system.
- Mandating use of this three tier mechanism in 102 cities.

10.1.2. Extensive Plantation Drive:

- Plantation initiatives under NCAP at pollution hot spots in the cities/towns
- to be undertaken under GIMs with Compensatory Afforestation Fund (CAF)
- being managed by National Compensatory Afforestation Management and
- Planning Authority (CAMPA).
- Development of plantation plans for the non-attainment cities/towns.
- Execution of city-specific plantation plans.
- Institutes as Indian Institute of Forest Management (IIFM), Universities

10.1.3 Technology Support:

- Clean Technologies with potential for air pollution prevention and mitigation will be supported for R&D, pilot scale demonstration and field scale implementation.
- The mechanism for such support will be formulated as an action plan.

10.1.4 Regional and Transboundary Plan:

- Various measures specially implementation of pollution abatement policies as Transport- Auto fuel policy for stringent norms for fuel and vehicles, road to rail/waterways, fleet modernization, electric vehicle policies, clean fuels, bye-passes, taxation policies, etc.;
- A comprehensive regional Plan to be formulated incorporating the inputs from the regional source apportionment studies.
- Linking NDC's target of additional forest and tree cover of 2.5 to 3 billion tonnes of CO2 equivalent by 2030 to NCAP. There needs to be more focus on the western regions of India (Rajasthan and Gujarat) for enhanced tree cover, which will reduce wind-blown dust within the country and will also act as barriers for trans-boundary dust.
- The initiatives under United Nations Convention to Combat Desertification (UNCCD) to be integrated for addressing the issue of transboundary dust.
- Air quality management at South-Asia regional level by activating the initiatives under 'Male Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia' and South Asia Cooperative Environment Programme (SACEP) to be explored.

10.1.5 Sectoral Interventions

10.1.5.1 Pollution from Road Dust and C&D (Construction and Demolition):

- Introducing mechanical sweepers on the basis of feasibility study in cities.
- Evolve SOP for addressing the specific issue of disposal of collected dust from mechanical sweeping, taking into consideration all the above cited factors.
- Stringent implementation of C&D Rules, 2016, and Dust Mitigation notification, 2018, of Government of India.

- Wall-to-wall paving of roads to be mandated.
- Stringent control of dust from construction activities using enclosures, fogging machines, and barriers.
- Greening and landscaping of all the major arterial roads and national highways after identification of major polluting stretches.
- Maintenance and repair of roads on priority.
- Sewage treatment plant-treated water sprinkling system along the roads and at intersecting road junctions and spraying of water twice a day before peak traffic hours.

10.1.5.2 Power Sector Emissions:

- Stringent compliance by all TPPs with respect to the emission norms according to the timelines upto December 2022 and as per the action plan prescribed in the direction dated December 2017 issued under EPA 1986.
- CGD network distribution shall be taken up on priority within the country, emphasizing on 102 non-attainment cities.
- There is need for optimizing the use of the existing power plants by prioritizing capacity utilization of natural gas/ clean fuel-based thermal power plants.
- Phasing out older coal-based power plants and converting specific coal based power plants to natural gas.
- Emphasizing the expansion of renewable power initiatives prioritizing the use of existing framework of NAPCC in non-attainment cities.
- Need to explore the possibility of Flyash utilization in extensive way in 102 non-attainment cities.

10.1.5.3 Industrial Emission:

- Introduction of gaseous fuels and enforcement of new and stringent SO2/NOx/PM2.5 standards for industries using solid fuels.
- Stricter enforcement of standards in large industries through continuous monitoring.
- Full enforcement of zig-zag brick technology in brick kilns.
- Elimination of DG set usage by provision of 24x7 electricity.
- Control by innovative end of pipe control technologies.
- Evolve standards and norms for in-use DG sets below 800 KW category.
- For DG Sets already operational, ensure usage of either of the two options: use of retrofitted emission control equipment having a minimum specified
- PM capturing efficiency of at least 70%, type approved by one of the 5 CPCBrecognized labs; or (b) shifting to gas-based generators by employing new gas-based generators or retrofitting the existing DG sets for partial gas usage.
- Utilize the Gujarat case study for a compelling case for other states to adopt third-party audits for polluting industries for enhancing implementation(States).

10.1.5.4 Transport Sector Emission:

- Stringent implementation of BS VI norms all over India by April 2020.

Green Mobility

- Stringent implementation of National Biofuel Policy with respect to ethanol and biodiesel blending target of 20% and 5%, respectively by 2030.
- City action plans to review the extension of MRT in cities/towns.

- Improvement and strengthening of inspection and maintenance system for vehicles through extension of I&C centres.
- Stringent implementation of PUC certificate through regular inspection and monitoring.
- Reducing real-world emissions by congestion management.
- Review the Green Corridor Project and feasibility of its extension with reference to 102 cities.
- To review the scaling up of Pilot project of MoPNG for introducing CNG in 2-wheelers and ensure timely implementation.
- Scaling up of R&D on use of Hydrogen as transport fuel.

E-mobility

- Formulation of a national-, state-, and city-specific action plan for e-mobility.
- Rapid augmentation of charging infrastructure in the country focusing on 102 cities.
- Central government offices fleets older than 15 years to be shifted to electric vehicles.
- Government-run buses for public transport, private buses, and 3-wheelers to be converted to EVs.
- Gradual transition to e-mobility in the 2-wheeler sector.
- Specific allocations for creating a venture capital fund.
- Investment in R&D and pilots focusing on the indigenization of battery manufacturing, cheap alternate resource to lithium and cobalt, resource efficiency associated with a circular economy, re-use and recycling for lithium batteries, etc.

10.1.5.5 Agricultural Emission:

- Evaluate the status of implementation of the above scheme in the states and impact on reduction of air pollution in Delhi and the NCR.
- Evaluate the socio-economic feasibility for implementation of ex-situ options like production of Prali-Char, biochar, pellets, briquettes, bioCNG, bioethanol, etc., as ex-situ solutions for management of crop residue burning especially with NPB in place.
- Extending the initiatives for addressing the issue of crop residue burning from the NCR to other part of the country and from paddy to sugarcane and other crops.
- Coordination with ISRO for regular availability of Remote Sensing Monitoring data for crop burning by the farmers.
- Implement plan for management of agricultural emissions The capacity-building initiatives for Krishi Vigyan Kendra (KVK) shall bestrengthened.

10.1.5.6 Emissions from Unsustainable Waste Management Practices:

- Use the smart cities framework to launch the NCAP in the 43 smart cities falling in the list of 102 non-attainment cities.
- Transform our centralised waste disposal infrastructure to a sustainable decentralized system in 102 cities.
- Source segregation into dry and wet waste to be made mandatory through involvement of municipalities and the RWA.
- Mandatory Training and capacity building of municipalities and the RWA.
- Transitioning towards a zero-waste pathway through an integrated solid waste management strategy, including targeting waste prevention, recycling, composting, energy recovery, treatment, and disposal.
- Waste reduction schemes such as 'polluters pay' principle, recycling projects, composting, biomethanation, RDF plants and co-processing to be supported under an integrated solid waste management strategy.

- Construction of decentralized compositing plant, biomethanation plant and C&D waste plants.
- Deployment of fixed compactor and doing away with dhalaos.
- Focus on training municipalities and SPCBs to be on national and international technologies for integrated waste management options.
- Stringent implementation and monitoring for extended producer responsibility for e-waste and plastic waste.
- Strict implementation of existing six waste management's rules on solid, Hazardous, Electronic, Bio-medical, Plastics and C&D waste.
- The Swachh Bharat Mission and National Mission on Sustainable Habitat to be used as a platform to push the objectives under this sector.

10.1.5.7 Indoor Air Pollution Management:

- Building specific guidelines and protocols on monitoring and management of indoor air pollution.
- Extend PMUY in 102 cities/towns and the associated village areas.
- Guidelines and provisions for building designs that define proper ventilation, clean cooking, and living areas to maintain healthy air quality inside the house to be integrated with the Pradhan Mantri Awas Yojana (PMAY).

10.1.6 City Specific Air Quality Management Plan for 102 Non-Attainment Cities:

- Preliminary city-specific action plans to be formulated for 102 non-attainment cities.
- City-specific action plans to be taken up for implementation by State Government and city administration.
- City-based clean air action plans are to be dynamic and evolve based on the available scientific evidence, including the information available through source apportionment studies.
- A separate emergency action plan in line with GRAP for Delhi to be formulated for each city for addressing the severe and emergency AQIs.

10.1.7 State Action Plan for Air Pollution:

- Preliminary State Action Plan for Air Pollution to be formulated for all 23 states which harbour 102 non-attainment cities;
- State Action Plan for Air Pollution to be taken up for implementation by State Government and city administration;
- The State Action Plan to have detailed funding mechanism.

In nutshell, the NCAP 2019 programme of Govt. of India focus on 102 polluted Indian cities and aims to reduce PM2.5 levels 20-30% over the next five years. The prime question whether that is enough when 14 out of 15 most polluted of the world are in India? The Air Pollution mitigation programme should infect recognise the Air pollution problem as a National emergency and should address the issue on war footings by taking the monster head on.

In long term, NCAP also need to scale-up its vision as well as actions significantly to ensure that the air pollution mitigation program is able to match the challenge of rapid economic growth as envisaged to make Indian economy grow to US $5 trillion by 2024 and US $10 trillion by 2030.

There is a lot to learn from our neighbours, namely China and Singapore that piecemeal approach would not help. Further in an age of innovation infinite, why settle for 20-30% reduction in 5 years. Why nor set the goal of making the National Capital, Its settelite Mega Cities like, Gurgaon, Faridabad and Noida as the World Cities guaranteeing Air Quality that meets the Global Standards of Air Quality that requires PM2.5 below 10 and PM10 below 20.

The task looks impossible, but the age of innovation infinite promises success in making impossible possible. If China can make Beijing, once lebelled as one of most polluted city in the world, but now it is out of the rank of top 200 most polluted cities of the world with PM2.5 now at 42.6. It was at in top 20 most polluted cities list as per AQI in 2014 at number 14.

The present Symposium shall focus on strategies and actions to further strengthen the NACP 2019 of Govt of India so as to achieve the success of the kind that China and Singapore have achieved during the last five years. The immediate focus should however be on Delhi and NCR, now that 5 out of 14 most polluted cities of world are Delhi and its satellite towns like Gurgaon, Faridabd, Noida and Gaziabad.

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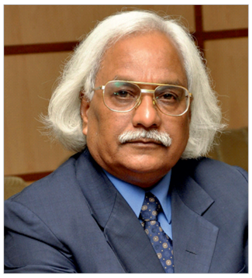
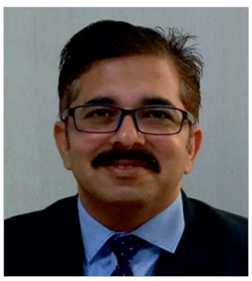


Prof. P.B. Sharma

A reputed academician, Prof. P.B. Sharma, currently the Vice Chancellor of Amity University Haryana had been the founder Vice-Chancellor of Delhi Technological University and also founder Vice-Chancellor of Rajiv Gandhi Technology University. Prof. Sharma is a former Professor of IIT Delhi, former. A Doctorate from University of Birmingham, UK, Prof. Sharma during his long professional career spanning over 50 years has made distinguished contribution to the advancement of frontiers of knowledge in the areas of Mobility Engineering, Power Plant Engineering, New and Renewable Energy Resources and Knowledge and Innovation Management.

Prof Sharma is the Chief mentor of the Interdisciplinary Research Cluster of Air and Water Pollution at AUH.



Dr. Atul Thakur

Dr. Atul Thakur obtained his M.Phil and Ph.D. degree in Nano Science from Himachal Pradesh University. He has published more than 100 research papers in SCI and Scopus indexed journals. Dr. Atul Thakur was selected for Post Doctorate research position at the Electronics Department of the University of Brest, France for two years. Taiwan National University. Dr. Atul Thakur has filed ELEVEN patents to date. He has successfully completed several government-funded projects sponsored by ANR, DRDO, MNRE, DAE, etc. Recently, Dr. Thakur bagged prestigious International grants from the Royal Academy of Engineering UK. Currently, he is working as a Director, Amity Institute of Nanotechnology, Amity University Haryana.

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Appendix –I

Amity University Haryana Air Quality Monitoring Facilities

1. Climate Research Laboratory (CRL)

A multi-disciplinary and multi-institutional Climate Research Laboratory (CRL) facility has been established with a suit of world-class equipment involving cutting-edge technology at AUH (Figure 1). This unique facility has been applied for characterizing aerosols, gases and

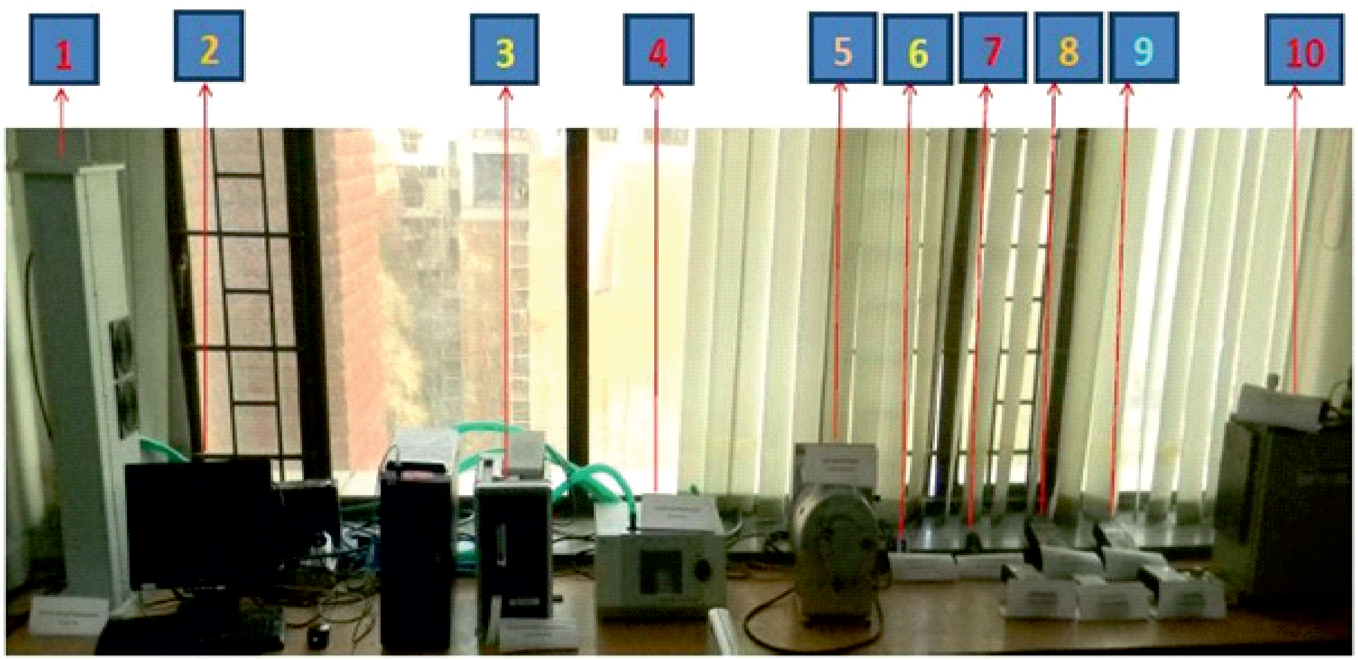

Figure 1: Climate Research Laboratory (CRL) at AUH: (1) Three-wavelength Integrating Nephelometer, (2) Dedicated computer for on-line parameter setting and data acquisition; (3) Seven-wavelength Aethalometer; (4) Aerodynamic Particle Sizer; (5) High Volume Sampler; (6) Micro-Aethalometer; (7) Portable Weather and Environmental Meter; (8) Multi-spectral Sun- photometer; (9) Multi-wavelength Ozone and Water Vapor Monitor and (10) Aerosol Particle Monitor.
rainwater, and studying their impact on human health, monsoon and climate. Using the high-resolution, continuous and long-term measurements, being made from these instruments coupled with satellite products and numerical models, innovative research on regional/global air quality, health, energy, earth's radiation budget, hydrological cycle, weather and climate will be pursued. Since such results are, so far, not available over this rural region of Haryana State, these studies play a pivotal role in the present and future air pollution, rainfall and climate change scenarios.

By coupling the real-time measurements of atmospheric constituents made with the CRL-AUH facility, with satellite products and numerical models, innovative research studies on regional/global air quality, health, energy, earth's radiation budget, hydrological cycle, weather and climate have been carried out. Since such studies are, so far, not available over this complex valley-like rural terrain, enveloped by Aravalli hillocks of Haryana State, they play a vital role in the present and future air pollution, health, rainfall and climate change scenarios. Many research activities, including special observation campaigns have been organized successfully. A workshop on **"Role of Aerosols in Air Quality, Monsoon and Climate"** has been organized at AUH on 08 January 2015. In brief, the centres have remarkably pursued the science of air quality, health and climate. It is generally observed that the values of Black Carbon (BC) emissions are alarming even at this rural location (~ 15 µg m-3) compared to the global average of ~ 4 µg m-3. PM1, 2.5, 10 have serious effects on agriculture and human health. Albeit the observations indicate that they are within the prescribed limits, but sometimes, throughout the year, there are severe upsurges, particularly during winter and dust-laden months of April and May, when they rise beyond prescribed safe limits. So, continuous monitoring, modeling and assessment of air quality are highly essential.

Apart from several research studies related to the influence of atmospheric aerosols (both primary and secondary) and of both natural anthropogenic origin, on regional air quality, health, clouds, water, energy, weather and climate, and their association with state variables such as wind, temperature, humidity, visibility, special studies during episodic events like dust storms, festivals etc. have been conducted. some interesting results from stand-alone measurements in the AUH campus, this versatile ground-based facility together with a mobile pollution monitoring system has been utilized in a major campaign during both the phases of Odd-Even Initiative of the Delhi Government to mitigate air pollution in and around the Delhi NCR region during the winter and summer epochs of 2016 (detailed reports have been brought out separately), and during the festive periods like Diwali, Holi etc., which are enumerated in the sections to follow.

2. Amity Air Quality Monitoring Station (AAQMS)

Air quality is an important determinant of health. There is convincing, and growing, evidence linking the risk of disease and premature death with exposure to fine particulate matter (PM2.5) and ozone (O3). The current public health burden of exposure is substantial. Ozone and several components of PM2.5, such as black carbon, are short-lived climate pollutants affecting the health of ecosystems. Other common air pollutants, such as nitrogen dioxide (NO2) or carbon monoxide (CO) are damaging to health as well, although quantification of the health burden related to such pollutants in the global population remains a challenge. By keeping these aspects in view, a MAPAN (Modeling of Air Pollution And Networking (MAPAN) system, hereafter called as AAQMS, an overshoot of SAFAR (System of Air-Quality Forecasting And Research), displayed in Figure 1[A, B, C], has been set-up in May 2017 at Amity University Haryana (AUH), Panchgaon-Manesar-Gurugram, in collaboration with Indian Institute of Tropical Meteorology (IITM-MoES), Pune. This versatile, real-time, research-mode, system yields 24x7 high-resolution data composed of 22 parameters (PM1, PM2.5, PM10, CO, CO2, NOx, NO2, NO, NH3, SO2, O3, Benzene, Ethyl Benzene, Toulene, Xylene, MP Xylene, Wind Speed, Wind Direction, Temperature, Humidity, Pressure and Rainfall), describing the quality of air in and around the AUH campus in Panchgaon and beyond. This emission inventory, in conjunction with such data from other network stations in the country, serves as a valuable reference (bench-mark) input to the models to predict or forecast the local and regional air quality.

[A] [B] [C]

Figure 1: *[A] Front-view of AAQMS with Display Board on the top at AUH, Gurgaon and Calibration Units inside, [B] Rack-mounted PM, Gas Analyzers and [C] Data Portal.*

The initial results obtained from the data recorded at Panchgaon, a rural station, indicate diurnal variation of Particulate Matter (PM) with a bi-modal distribution, first peak in the morning hours due to local pollution, and the second one, which is a broader peak in the late evening hours due to plying of the slow-moving heavy vehicles in the National Highway (NH-8), which is about 5 km away from the MAPAN station. With a view to emphasize such observations over a rural site (Panchgaon), the concurrent data from Central Pollution Control

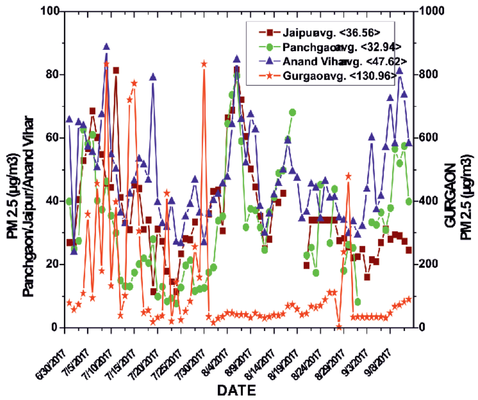

Fig. 2: Multi-site daily mean variations in PM2.5 mass concentration

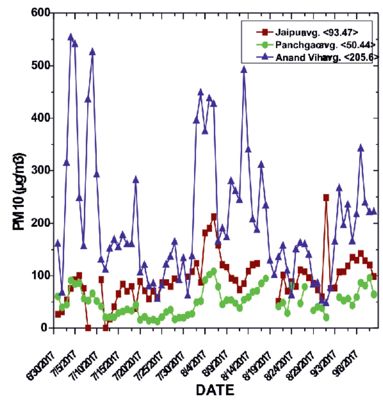

Fig. 3: Multi-site daily mean variations in PM10 mass concentration

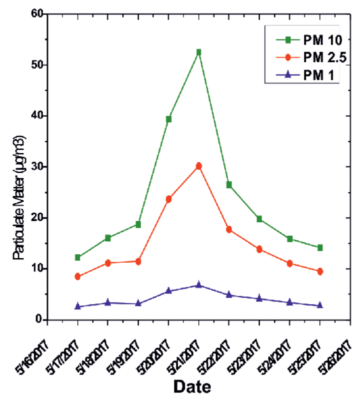

Fig.4: Daily mean variations of PM1, PM 2.5 and PM 10, observed during a dust-storm from17 to 25 May 2017

Board (CPCB), archived over some typical sites in the vicinity of AUH for the period from 1 July to 12 September 2017 have been examined. The overall mean picture for each station is also indicated in the figures 2 & 3. It can be clearly seen that in almost all cases, the pollutant concentration over Panchgaon is lower as compared to those at other stations, which is primarily due to geographical location of the site. The concentration levels over this place can be considered as near-reference values, against which the air quality over any other surrounding polluted location can be estimated. Figure 4 depicts the multi-site daily mean variations in PM1, PM2.5 and PM10 during a dust-storm that occurred between 17 and 25 May 2017, with a peak activity on 21 May 2017. It is also quite evident that mass concentration increases with increase in particle size. Also, coarse-mode (PM10) particle mass concentration is higher than the other two (PM1 and PM2.5) during the dust-storm period, which is consistent.

2.3 Research Highlights

- Studied the pollution effects on human health. Respiratory tract infection diseases, namely, ARI (Acute Respiratory Infection) and URI (Upper Respiratory Infection), recorded from patients' admission data of Government hospitals in Dharuhera and Manesar (situated in the proximity of AUH, Manesar) analyzed.
- Significant association was found between Particulate Matter (dust level), ARI and URI.
- Correlation between PM level and disease parameters showed both positive and negative depending on atmospheric stability conditions.
- Higher values of Angstrom Exponent (abundance of fine dust particles) showed greater association with the respiratory tract infection diseases.
- Dust content over the experimental site is found to influence the surrounding humans with a delay of around 2 days.
- Investigated morphological aspects of dust around the experimental station.
- Investigated the physico-chemical characteristics of Haze-Fog in the study region.
- Health effects of air pollutants have been studied using WHO Models.

Apart from publication of results in Refereed Journals, text book chapters and presentation at Conferences / Symposia / Workshops, several important findings from the Climate Research Laboratory, Amity Air Quality Monitoring System and Solar Radiometer Facilities, available with Amity University Haryana have also been discussed with press media and published in daily News Magazines. Details are furnished below:

Table: Details of the Press Releases of the Results of AUH Air Monitoring Experiments

S. No.	Type of Publication	Short Description/Evidence
1.	Article in Newspaper (Hindustan Live)	Delhi NCR Pradushan pur Amity me Churcha.
2.	Article in News Paper (India Education Diary)	News on Air Pollution.
3.	Article in News Paper (The Times of India)	News on “High Pollution Levels Affect Crop Yield”.
4.	Article in News Paper (The Times of India)	News on “Analyze Economic Health Impacts to Fight Pollution”.
5.	Article in Newspaper	Amity Registers Dip in Pollution on Campus.
6.	Article in Newspaper	Black Carbon Level in Air Down 50% Since Dec 31, Study Shows.
7.	Article in Newspaper	Som-Visham Formula Se Pradhushan me Kamee (Hindi version).
8.	Article in Newspaper	Amity University Ke Shodh Me Sum-Visham Safal (Hindi Version).
9.	Article in Newspaper	Amity Gurgaon Says Pollution Down in Campus After Start of Odd-Even Run.
10.	Article in Newspaper	Varsity to Monitor Impact of air quality
11.	Article in Newspaper	Level of Pollutants has Dipped: Study.

Appendix –II

Air Quality Index (AQI)

AQI	Associated health impacts
Good (0 – 50)	Minimal impact
Satisfactory (51 – 100)	Minor breathing discomfort to sensitive people
Moderately polluted (101 – 200)	Breathing discomfort to people with lungs, asthma, and heart diseases
Poor (201 – 300)	Breathing discomfort to most people on prolonged exposure
Very poor (301 – 400)	Respiratory illness on prolonged exposure
Severe (401 – 500)	Affects healthy people, and seriously impacts those with existing diseases

AMITY UNIVERSITY GURUGRAM HOSTED AN INTERNATIONAL SYMPOSIUM ON AIR POLLUTION - CAUSES, MITIGATION AND STRATEGIC PLANNING

Amity University Gurugram, India's leading private university, organized an International Symposium on Air Pollution – Causes, Mitigation & Strategic Planning at its campus on 20th September 2019. Noted scientists, environmentalists and other experts from across the world ascertained the potent causative factors for the enormous threat of air pollution to the modern civilization and its rational curbing and remedial measures.

At the symposium, the distinguished panelists presented various perspectives on air pollution, identified gaps and their possible solutions through strategic planning as next steps to curb the issues.

Chairing this notable event, Dr. Aseem Chauhan, Chancellor, Amity University Gurugram, said: “Amity University is committed to bringing together the best experts from around the world to be a part of the solutions to the devastating air pollution problem. We have also identified key sources of pollution and their probable solutions over the last years though our Center for Air Pollution. Amity University Gurugram is making sustained efforts to ward-off such a colossal environmental hazard. An AQI measurement system has been established at the University for continuous monitoring of air quality in Delhi NCR.”

Prof. (Dr.) P. B. Sharma, Vice Chancellor, Amity University Gurugram, said, “Air Quality of Delhi and NCR region became major concern when AQI touched 999 in the month of October 2015. At Amity University Gurugram, we took the call as early as October 2015 to establish a Center of Environmental Health Sciences and jointly with our ACOAST (Amity Centre for Ocean Atmospheric Science and Technology) and in collaboration with IITM Pune have engaged seriously to monitor, model and analyze the air pollution and its trajectories.” He further added, “Our monitoring is based on a state-of-the-art Air Quality Monitoring Station SAFAR established within our campus by IITM and Ministry of Earth Sciences, Govt. of India. Our efforts on air pollution studies are further strengthened by NASA Aeronet that is installed in our ACOAST and has enabled us to study aerosol particles ranging from 1 nanogram to 1000 microgram sizes and trace the trajectories of aerosol travelling from as far as the oil producing Arabic countries.”

“Given its rapid transition, a significant portion of India’s population is subjected to both kinds of risk at once the so-called risk overlap. This is particularly apparent in urban slums which maintain the environmental risks of poverty but are often subjected to the greatest of the modern environmental risks. This set of conditions overall form the Environmental Health Risk Transition”, said Dr. Qamar Rahman, Distinguished Scientist, Amity University Uttar Pradesh, Lucknow Campus.

Air quality of Delhi NCR region has been a matter of grave concern for the last few years. Air pollution has claimed over 7 million lives in a year and has become a major cause of non-communicable diseases such as heart attacks, strokes and lung cancer worldwide. It also accelerates climate change. Tackling it can help reduce health risks related to weather extremes, sea level rise, drought and food production.

The Central Pollution Control Board (CPCB) and National Environment Engineers Research Institute (NEERI) have declared vehicular emission as a major contributor to air pollution of Delhi NCR.

Delivering his keynote address, Dr. Kirk R. Smith, said that "household pollution if effectively cut down shall alone solve much of the air pollution in India". He also emphasized that we need to emulate some of the best practices from China, Singapore and New York to make NCAP more effective.

Dr. Arthur Frank said air quality has a direct bearing on human health and must be given utmost priority in India.

Dr. Alena Bartonova shared the best practices of EU Clean Air Program which laid great emphasize on effective implementation of air quality standards.

The notable speakers on the panel included Dr. Kirk R. Smith (Berkeley University), Dr. Arthur Frank (Drexel University, Philadelphia), Dr. Alena Bartonova (Norwegian Institute for Air Research Center), Dr. M. Mohapatra (DG of IMD and Earth Science Department, GoI), Professor Mukesh Khare (IIT, Delhi), Professor Dr. Gufran Baig (IITM, Pune), Dr. Qamar Rahman (Distinguished Scientist, AUUP, Lucknow Campus), Dr. P Kakkar (Head, CSIR – IITR, Lucknow) and Dr. Sumit Sharma (Director Earth Sciences, TERI).

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