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INTRODUCTION

It is shocking to know that out of the top twenty most polluted cities in the world, thirteen are in India. Allahabad, Agra, Lucknow, Kanpur, Amritsar etc. are among the list of top 20 most polluted cities in the world. Pollution is a real threat to health and well being of mankind. Studies by WHO reveal that globally seven million people died because of exposure of air pollution. Those include death due to exposure to toxic pollutants both inside house and in the environment.

in India, particularly in cities and air pollutants including particulate matter (PM), sulphur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO), and ozone (O3) often exceed the National Ambient Air Quality Standards (NAAQS). According to the World Health Organization (WHO), 37 cities from India feature in the top 100 world cities with the worst PM10 pollution, and the cities of Delhi, Raipur, Gwalior, and Lucknow are listed in the top 10 (WHO, 2014). A similar assessment by WHO, in 2011, listed 27 cities in the top 100. More than 100 cities under the national ambient monitoring program exceed the WHO guideline for PM10.

In India, the national ambient standard for CO is better than the WHO guideline. The NO2, SO2, and O3 standards are at par with the guidelines. However, the standards for PM10 (Aerodynamic diameter <10 µm) and PM2.5 (aerodynamic diameter <2.5 µm) are lagging.

In 2010, the Central Pollution Control Board (CPCB) developed the Comprehensive Environmental Pollution Index (CEPI), a methodology to assess air, water, and soil pollution at the industrial clusters in the country. While industries typically rely on the grid electricity for operations and maintenance; frequent power cuts often necessitate the use of inset electricity generation (using coal, diesel, and heavy fuel oil), which adds to the industrial air pollution load. The study identified 43 clusters with a rating of more than 70, on a scale of 0 to 100, and listed them as critically polluted for further action. Most of these clusters are in and around major cities – most notably Korba (Chhattisgarh), Vapi (Gujarat), Faridabad and Ghaziabad (outside of Delhi), Ludhiana (Punjab), Kanpur and Agra (Uttar Pradesh), Vellore and Coimbatore (Tamil Nadu), Kochi (Kerala), Vishakhapatnam (Andhra Pradesh), Howrah (West Bengal), and Bhiwadi (Rajasthan).

The global burden of disease (GBD) assessments, listed outdoor air pollution among the top 10 health risks in India. The study estimated 695,000 premature deaths and loss of 18.2 million healthy life years due to outdoor PM2.5 and ozone pollution (IHME, 2013). Among the health risk factors studied, outdoor air pollution was ranked 5th in mortality and 7th in overall health burden in India. Household (indoor) air pollution from burning of solid fuels was responsible for an additional one million premature deaths. A substantial increase was observed in the cases of ischemic heart disease (which can lead to heart attacks), cerebrovascular disease (which can lead to strokes), chronic obstructive pulmonary diseases, lower respiratory infections, and cancers (in trachea, lungs, and bronchitis). Several other studies have estimated premature mortality rates due to outdoor PM pollution for several Indian cities, using similar methodologies.

While the field of air pollution and atmospheric science is gaining ground in India and there has been a surge in the published research, much of the knowledge is widely scattered. While reviews in the past have provided scientific recommendations (Pant and Harrison, 2012; Krishna, 2012), there has been no concerted effort towards addressing the various aspects of the air pollution (source to impacts), and providing a global summary as well as gaps in current knowledge. Existing local (and international) knowledge can be leveraged in designing effective interventions in India, where pollutant sources are often complex. In this paper, we aim to present an overview of the emission sources and control options for air quality improvements in Indian cities, with a particular focus on key sectors such as transportation, dust, power plants, brick kilns, waste, industries, and residential. Also included is a broad discussion on key institutional measures necessary for building an effective air quality management plan.

Using improved air pollution methods in GBD 2017, we provide detailed findings on the exposure to ambient particulate matter pollution and household air pollution, and their separate impacts on deaths, disease burden, and life expectancy in every state of India, as well as the impact of overall air pollution, to inform policy and interventions.

Major Air Pollutants

The major sources of air pollution in India and around the globe are automobile exhaust and industrial emissions. The prime air pollutants have been broadly classified as outdoor and indoor pollutants (Fig.1). Outdoor pollutants include remains of fossil fuel, carbon particles and metallic particles in the atmosphere from industrial and automobile emissions, toxic gases i.e., nitrogen dioxide, carbon monoxide, sulphur dioxide etc. and ozone, tobacco smoke etc. On the other hand indoor pollutants include toxic gases produced from kitchen fuels, building materials i.e., asbestos, lead etc. tobacco smoke etc. Delhi has been found to have the highest concentration of “Respiratory Suspended Particulate Matter”(RSPM) in the air. The concentration of RSPM in the air of Delhi is highest than that found in the air of the other metro cities of India.

The Most Polluted City In The World Is In India!

New Delhi is a busy metropolitan city, the capital of India. In May 2014, Particle Matter (PM) of size less than 2.5 micrometres in diameter measured concentrations was found to be greater than 350 micrograms per cubic meter of air in the city of New Delhi, making the city the most polluted city in the world as per WHO. This enhanced concentration of PM of various sizes in atmosphere is due to increasing automobile exhaust and increase of coal fuelled factories in the cities. According to WHO report, Delhi is the worst polluted city in the world and the major source of the particulate matter i.e. solid and liquid particles of diameter less than 2.5 micro meter are the smoke coming out from industries in the city.

Using improved air pollution methods in GBD 2017, we provide detailed findings on the exposure to ambient particulate matter pollution and household air pollution, and their separate impacts on deaths, disease burden, and life expectancy in every state of India, as well as the impact of overall air pollution, to inform policy and interventions.

OBJECTIVES

Clean air is essential for the well being of people and other living beings. But the air is getting polluted day by day. It is mainly because of vehicular emissions and industrial exhaust. There are also other reasons that causes air pollution. As the air gets polluted concentration of harmful gases like carbon monoxide, sulphur oxides, nitrogen oxides, methane, CFCs increases in the atmosphere. Increase of CFCs in atmosphere leads to ozone hole which allows the ultraviolet rays of the sun enters the earth which increases the rate of skin cancer, eye cataracts, genetic and immune system damage in humans and other living beings. Other pollutants also causes several diseases in organisms which may ultimately lead to death.

This dissertation highlights the following objectives based on which the overall survey of dissertation has been done to get a vivid idea of the causes and impacts of air pollution in India.

We have the following research coordination objectives:-

- Quality of the Air
- Sources that causes air pollution- which includes outdoor and indoor pollutants.
- How air pollution effects humans as well as the climate of the country.
- How to reduce air pollution.

AIR QUALITY IN INDIAN CITIES

1.Air Quality Data

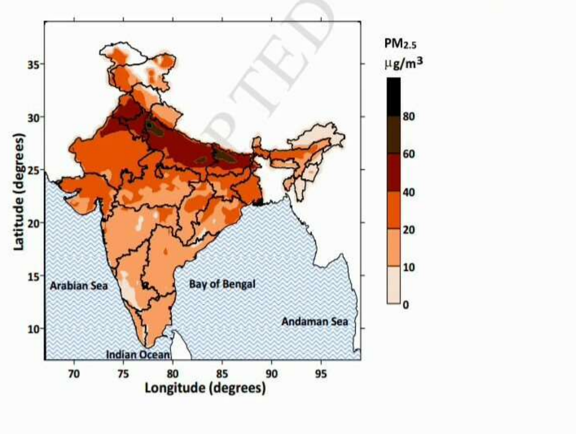
The national ambient monitoring program collects 24-hour averages of key air pollutants 2-3 times per week at 342 manual stations in 127 cities and is managed by CPCB. However, only a limited number of cities operate continuous monitoring stations, measuring the full array of criteria pollutants and as such, access to the monitoring data is limited. A summary of the measurements for PM10, SO2, and NO2 for 2009-10 is presented in Table 1. Delhi and Pune also have citywide monitoring networks outside the national framework.

To supplement the data generated at on-ground monitoring stations, several studies have utilized satellite data to derive global ground-level ambient PM2.5 concentrations (Van Donkelaar et al., 2010). These were utilized for the GBD assessments (IHME, 2013). An extract of this data covering India is presented in Figure 1. Since the satellite extractions are available at 0.1° resolution (~10 km), there is some uncertainty associated with these derivatives and these retrieval methods are being improved every year, to complement the on-ground measurements. For example, most of southern India in Figure 1 seems to comply with the WHO guideline of 15 µg/m3. However, the urban pollution levels here are some of the highest in the country including Chennai and Coimbatore (Tamil Nadu), Hyderabad and Vishakhapatnam (Andhra Pradesh), Kochi (Kerala), and Bengaluru (Karnataka).

The Indo-Gangetic plain has the largest number of brick kilns, with old and inefficient combustion technology, using a mix of biomass and coal for combustion needs (Maithel et al., 2012). The states of Bihar, West Bengal, Jharkhand, Orissa, and Chhattisgarh harbour the largest coal mines in the country, and a cluster of power plants around the mines (Guttikunda and Jawahar, 2014). Several large power plants also exist in the states of Punjab, Haryana, Delhi and Uttar Pradesh, making the north and north-eastern belt the most polluted part of the country. The cities in the north are also landlocked, which are also affected by the prevalent meteorological conditions, unlike some of the Southern cities with the privilege of land-sea breezes (Guttikunda and Gujrat, 2012).

Besides PM2.5 concentrations, the satellite observations can also help estimate the concentrations of SO_2, NOx, and CO, and help analyse the severity of on-ground anthropogenic and natural emission.

Figure 1: Ambient $PM_{2.5}$ concentrations derived from the satellite observations



Air pollution from a coking oven.

Table 1: Cities at a glance

City	AR	Pop	A	B	C	D	E	F	PM10 (μg/m³)	SO2 (μg/m³)	NO2 (μg/m³)
Hyderabad	500	7,749,334	155	50%	14%	32%	70.82 (40)	No	81.2 ± 34.0	5.0 ± 2.4	22. ± 7.0
Vijayawada	79	1,491,202	189	26%	4%	21%		No	79. ± 14.9	4.6 ± 0.5	13.5 ± 3.1
Vishakhapatnam	159	1,730,320	109	36%	8%	21%		Yes	91.2 ± 34.8	11.9 ± 12.7	29.1 ± 13.8
Guwahati	145	968,549	67	10%	3%	80%		No	132.6 ± 89.9	8.1 ± 3.3	16.6 ± 5.3
Patna	86	2,046,652	238	32%	10%	29%		No	138.8 ± 84.4	5.3 ± 2.8	32.9 ± 18.8
Korba	39	365,073	94	43%	8%	56%		No	116.9 ± 17.	13.3 ± 0.7	21.3 ± 0.8
Raipur	95	1,122,555	118	38%	9%	48%	65.85 (63)	No	272.2 ± 43.3	17.8 ± 3.7	45.9 ± 2.7
Delhi	669	16,314,838	244	39%	21%	9%		No	260.1 ± 117.1	6.5 ± 4.2	51.1 ± 17.2
Ahmedabad	275	6,352,254	231	51%	13%	24%	75.28 (22)	No	94.3 ± 21.8	15.9 ± 3.5	20.9 ± 4.0
Rajkot	86	1,390,933	162	60%	10%	33%	66.76 (59)	No	105.6 ± 27.	11.3 ± 2.1	15.4 ± 2.6
Surat	155	4,585,367	296	44%	9%	28%	57.9 (79)	No	89.1 ± 13.1	18.6 ± 3.9	26.3 ± 3.2
Vadodhara	145	1,817,191	125	60%	14%	20%	66.91 (57)	No	86. ± 34.6	16.2 ± 5.8	30.2 ± 13.1
Vapi	37	163,605	44	44%	11%	32%	88.09 (2)	No	78.3 ± 8.1	16.4 ± 1.9	23.9 ± 1.7
Yamuna Nagar	41	383,318	93	42%	13%	24%		No	281.5 ± 132.3	12.7 ± 2.7	27.1 ± 3.3
Dhanbad	45	1,195,298	266	31%	5%	72%	78.63 (13)	No	164. ± 95.5	16.6 ± 3.5	41. ± 8.9
Jamshedpur	119	1,337,131	112	49%	12%	38%	66.06 (61)	No	171.7 ± 13.4	36.4 ± 2.2	49.3 ± 3.9
Ranchi	106	1,126,741	106	43%	13%	36%		No	178.9 ± 67.9	18.1 ± 2.2	31.6 ± 3.0
Bangalore	556	8,499,399	153	46%	18%	20%		No	109.4 ± 92.6	15. ± 3.1	37.5 ± 6.0
Jammu	123	651,826	53	48%	25%	13%		No	118.2 ± 37.4	8.2 ± 4.4	12.7 ± 3.4
Trivandrum	108	1,687,406	156	34%	17%	43%		Yes	62.9 ± 17.8	9.7 ± 5.2	26.1 ± 5.2
Bhopal	178	1,883,381	106	48%	15%	30%		No	118.5 ± 73.2	7.1 ± 2.4	17.5 ± 5.9
Gwalior	78	1,101,981	141	45%	8%	29%	54.63 (83)	No	227.7 ± 84.6	8.6 ± 1.9	16.8 ± 4.1
Indore	102	2,167,447	212	50%	13%	17%	71.68 (38)	No	160.6 ± 73.4	9.4 ± 4.3	16.4 ± 6.5
Jabalpur	104	1,267,564	122	46%	8%	34%		No	135.7 ± 13.0		24.3 ± 2.1
Ujjain	33	515,215	156	40%	6%	26%		No	78.4 ± 42.0	10.9 ± 3.4	11.9 ± 3.1
Shillong	46	354,325	77	9%	16%	42%		No	78.8 ± 31.0	19.4 ± 19.0	12.5 ± 5.4
Amritsar	90	1,183,705	132	50%	15%	21%		No	188.7 ± 24.2	14.8 ± 2.2	35.1 ± 3.1
Chandigarh	115	1,025,682	89	47%	26%	27%		No	79.9 ± 32.6	5.8 ± 0.5	15.4 ± 7.8
Ludhiana	167	1,613,878	97	50%	19%	19%	81.66 (10)	No	251.2 ± 21.9	8.4 ± 2.3	36.2 ± 7.0
Chennai	426	8,917,749	210	47%	13%	17%		Yes	121.5 ± 45.5	12.1 ± 3.5	20.8 ± 7.0
Agra	129	1,746,467	135	48%	12%	27%	76.48 (19)	No	184.1 ± 95.9	6.6 ± 3.5	20.8 ± 12.1
Allahabad	71	1,216,719	171	54%	11%	26%		No	165.3 ± 70.7	3.6 ± 1.0	23.7 ± 15.9
Firozabad	21	603,797	288	25%	4%	40%	60.51 (75)	No	195.6 ± 78.2	21.6 ± 4.8	32.1 ± 4.9
Kanpur	150	2,920,067	195	11%	3%	42%	78.09 (15)	No	211.5 ± 25.3	7.5 ± 1.2	31.3 ± 4.9
Lucknow	240	2,901,474	121	52%	15%	20%		No	200.4 ± 28.4	8.4 ± 1.0	36.1 ± 2.6
Varanasi	102	1,435,113	141	40%	7%	29%	73.79 (29)	No	125.3 ± 8.4	17.2 ± 0.7	19.6 ± 0.7
Asansol	49	1,243,008	254	27%	4%	61%	70.2 (42)	No	162.7 ± 98.7	9.4 ± 3.1	61.8 ± 18.5
Durgapur	56	581,409	104	27%	4%	61%	68.26 (52)	No	172.5 ± 107.1	9.8 ± 3.2	63.9 ± 18.6
Kolkota	727	14,112,536	194	12%	9%	34%		No	160.8 ± 109.3	17.3 ± 15.4	59.7 ± 27.8

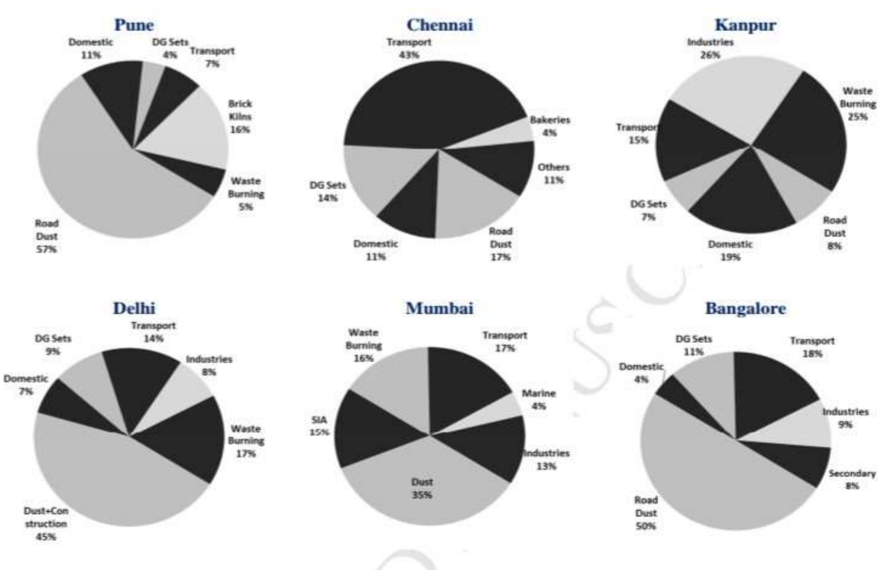
Notes:
AR = build-up area (in km²) is estimated from Google Earth maps.; A = population density (per hectare); B = % households with a motorized two wheelers; C = % households with a four wheeler; D = % households with a non-gas cookstove; E = CEPI rating (rank);
F = is the city coastal;

Sources of Air Pollution

For city administrators, regulating air pollution is the primary concern and accurate knowledge of the source contributions is vital to developing an effective air quality management program. The contribution of various sources to the ambient PM pollution is typically assessed via receptor modelling and this methodology has been applied in many Indian cities (CPCB, 2010; Pant and Harrison, 2012). However, between 2000 and 2013, 70% of the known studies were conducted in five big cities - Delhi, Mumbai, Chennai, Kolkata, and Hyderabad and very limited number in other cities, which are also listed as exceeding the ambient standards and WHO guidelines. The number of studies in various cities is presented in Table 3, with limited number of studies on PM2.5 size fraction.

The most commonly identified sources are vehicles, manufacturing and electricity generation industries, construction activities, road dust, waste burning, combustion of oil, coal, and biomass in the households, and marine/sea salt. A multi-city study was conducted by CPCB for six cities – Pune, Chennai, Delhi, Mumbai, Kanpur, and Bengaluru, at an approximate project cost of US$6 million (CPCB, 2010). A summary of this study is presented in Figure 2. Unlike the popular belief that road transport is the biggest cause of urban air pollution, the CPCB (2010) results showed that there are other sources which also need immediate attention and the road transport is only one of the major contributors to the growing air quality problems in the cities.

Figure 2: Average percent contributions of major sources to PM_{10} pollution (CPCB, 2010)



In the six cities, the share of road transport ranged 7% in Pune to 43% in Chennai. Along with Mumbai, Chennai harbors one of the largest commercial ports in India, which means a large number of diesel fuelled heavy duty trucks pass through the city, to and from the port, and thus increasing the share of road transport in ambient PM pollution.

Air pollution is caused by solid and liquid particles and certain gases that are suspended in the air. These particles and gases can come from vehicles,, factories, dust, pollen, mold spores, volcanoes and wildfires. The solid and liquid particles suspended in our air are called aerosols.

The major cause of air pollution is combustion and combustion is essential to man. When combustion occurs the hydrogen and carbon in the fuel combines with oxygen from the air to produce heat, light, carbon dioxide, and water vapour. However, impurities in the fuel, poor fuel to air ratio, or too high or too low combustion temperatures cause the formation of side products such as carbon monoxide, sulphur oxides, nitrogen oxides, fly ash, and unburned hydrocarbons, which all are air pollutants.

- As of Jan 2015, coal-powered thermal power plants account for 60.72% of India’s total power generation, according to data available from Central Electricity Authority (CEA). Coal plants happen to be one of the leading sources of SO2 and NO2. Industrial pollution is one of the most evident environmental problems experienced by now industrialized countries and majority of the newly industrializing economies are facing it today. Industrial pollution and waste encompass the full range of materials generated by industrial activities that are unwanted by the producer.
- As per Census 2011, 87% of rural households and 26% of urban households depend on biomass for cooking. Burning of biomass is a leading cause of indoor air pollution and is responsible for respiratory and pulmonary health issues in approximately 400 million Indians.
- Growing number of cars in Indian cities - Private & commercial vehicles account for 66.28% of the total consumption of diesel. Low standards for vehicle emissions & fuel have resulted in increased levels of Nitrogen Oxides & Sulphur.

- The proportion of rural households using kerosene as a primary source of energy for lighting is almost 30%. Kerosene.
- lanterns used in rural areas are a primary source of emission of black carbon soot and cause significant health impact, particularly in the case of women and children.

Industrial pollution

Industrial structural composition is one of the main determinants of pollution in any country. Liberalization has changed the structure of Indian industrial sector. On the basis of this we can analyse whether domestic manufacturing production has moved towards more pollution intensive industries as compared to less polluting industries. Industrial structure is being analysed on the basis of four parameters-types of industries, total employment, total output and net value added.

Coal-fired power plants

In 2011-12, there were 111 coal-fired power plants in India with a combined generation capacity of 121GW (CEA, 2012). The emissions and pollution analysis for these plants, resulted in an estimated 80,000 to 115,000 premature deaths and more than 20.0 million asthma cases from exposure to total PM2.5 pollution annually (Guttikunda and Jawahar, 2014). While Indian coal has a low sulphur content in comparison with other coals, ash levels are reported to be quite high and can contribute to coarse PM emissions (Pant and Harrison, 2012).

Despite the volume of coal used in the power generation sector, there are very few regulations in place to address these environmental and health costs. To date, for PM emissions, the emission standard in India lags to those implemented in China, Australia, the United States, and the European Union (Table 5). For other key pollutants, there are no prescribed emission standards despite the fact that India is a relatively dense country and several power plants are in close proximity to residential areas. Aggressive pollution control regulations such as mandating flue gas desulfurization, introduction of tighter emission standards for all criteria pollutants, and updating procedures for environment impact assessments are imperative for regional clean air and to reduce health impacts. For example, a mandate for installation of flue gas desulfurization systems could reduce the PM2.5 concentrations by 30-40% by eliminating the formation of the secondary sulphates and nitrates (Guttikunda and Jawahar, 2014).

Besides flue gas PM emissions, fugitive dust from coal-handling plants and ash ponds (after the disposal from the plants) is also a problem. According to Central Electrical Authority, after the combustion and application of control equipment, ash collection at the power plants range 70-80% of the total ash in the coal. In 2003, an amendment notification from MoEF mandated 25% bottom ash in all brick kilns within 100km radius of the power plant and all building construction within 100km to use 100% ash based bricks, blocks, and tiles. To date, percentage of ash utilized in the construction industry is low.

Fig 3. Coal fired power plant

Domestic Fuels

The issue of indoor air pollution is also critical because of the high magnitude of population getting exposed to such pollution every day (Venkatraman et al., 2010; Grieshop et al., 2011; Smith et al., 2014). According to GBD 2010 assessments, household air pollution has

been a persistent health hazard in India and has retained its position as the 2nd highest risk factor for disability life years lost and resulting in 1.0 million premature deaths annually (IHME, 2013). Several studies have characterized the impacts of household air pollution and health risks due to indoor solid fuel use in India (Balakrishnan et al., 2011).

In 2011, Non-LPG fuels are used in 35% of urban and 89% of rural households in India, compared to 52% and 94% respectively in 2001 (Census-India, 2012), with little improvement for the rural households. Keeping in view the magnitude of the health risks, the Ministry of Petroleum & Natural Gas of India aims to provide LPG connections to up to 75% of households in India by year 2015 (PIB, 2013). For the rural areas, the program is also proposing to set up community kitchens with LPG connections where users can pay as per usage. Alternatives like electric (induction) stoves are cleaner (with pollution generated somewhere else), but their usage is dependent on power supply in the rural communities. The use of electric stoves, in the urban centres, is increasing and currently limited by the cost of stoves.

Fig 4. Indoor air pollution caused by biomass burning.

Transport in Urban Air Pollution

Indian emissions inventories are not reliable; for example, transport emission inventories have tended to account only for vehicle exhaust, not for other vehicle and transport system sources, and have employed emission factors that do not adequately represent actual vehicle populations or in-use conditions. Besides, there are discrepancies between inventories generated by different agencies. Notwithstanding these issues, the available data show, in Delhi, for example, that motor vehicles are predominant in terms of carbon monoxide, hydrocarbons, and nitrogen oxides. And although their share of particulate and sulphur dioxide emissions is considerably lower than that of other sources, their contribution to these emissions and, more generally, the contribution of urban transport to air pollution are likely growing in Indian cities, given the rapidly growing motor vehicle activity. Note that the bulk of transport-generated particulates is PM10, which is strongly linked with morbidities and mortalities associated with respiratory and cardiovascular diseases.

While more recent model vehicles have been entering the market with economic liberalization since the 1990s, Indian motor vehicle technology has been decades behind global practice, and in some instances, 1950s and 1960s vintage vehicles continue to be manufactured. Motor vehicle activity in India has therefore been characterized by high pollution intensities. The vast majority of M2W vehicles, which form the bulk of India's motor vehicle fleet, and for-hire motorized three-wheeled (M3W) vehicles have until recently been powered by highly polluting two-stroke engines. Tests conducted in the early 1990s showed that these vehicles, which typically carry one to four persons, produced higher carbon monoxide and hydrocarbon and one-fourth the particulate emissions per kilometer relative to buses, which are themselves heavy polluters, especially in terms of particulates.

In addition to their high pollution levels, M2W vehicles are used intensively and, consequently, have accounted for significant shares of transport emissions. In Delhi in the mid-1990s, for example, these vehicles accounted for 60% of vehicle-kilometres in motorized passenger vehicles and approximately 30%–50% of exhaust carbon monoxide, hydrocarbon, and particulate emissions from all motor vehicle activity. Their contribution was marginal only in terms of nitrogen oxides and sulphur dioxide, for which buses and other diesel vehicles were primarily responsible. Thus, M2W and M3W vehicles have represented a serious problem in terms of emissions per passenger-kilometer.

Additionally, M2W vehicles alone consume around half of all gasoline nationally.

Fuel quality have also contributed significantly to transport air pollution. Until the mid-1990s, when significant improvements in fuel quality began to be implemented, lead content was excessively high (Table 2). Lead in gasoline has been a serious public health concern globally, because it is released predominantly in the form of PM10, and even low lead levels can cause neurological effects in children, which can persist even after exposure ends. Benzene, a known carcinogen implicated in adult leukaemia and lung cancer, and for which the WHO specifies no safe limit in air, was not controlled in Indian gasoline until recently (Table 2). Ambient benzene levels in Delhi in the late 1990s were an order of magnitude higher than those allowed by the European Union. Levels of sulphur, an important constituent in particulate emissions, were excessively high in Indian gasoline and diesel until the mid-1990s (Table 2), and several orders of magnitude higher than in their US and Californian counterparts at the same time.

	Gasoline				
	1993	1997	2000	2002	Proposed
Lead content, g/L max.	0.56	0.15		0.013	0.005
Sulfur, total, % by mass, max.	0.20	0.20; 0.15 in unleaded gasoline	0.10	As in 2000, but 0.02 in notified areas	0.015
Reid vapor pressure (RVP), kPa, max.	35–70	35–70	35–60	35–60	60
Benzene content, % by volume, max.	NS	NS	3 (metros) 5 (rest of country)	As in 2000, but 1 in notified areas	1
Olefin content, % by volume, max.	NS	NS	NS	NS	21
Aromatics content, % by volume, max.	NS	NS	NS	NS	42
Oxygen content, % by mass, max.	NA	NA	2.5	2.5	2.7
Existent gum, g/m^3, max.	40	40	40	40	40
Engine intake system cleanliness	NS	NS	MFA required; tests specified; limits specified in 2003		
	Diesel				
	1995		1999	2002	Proposed
Sulfur, total, % by mass, max.	1		0.25	0.05 in metros	0.035

kPa—kilopascals; MFA—multifunctional additive; NA—not applicable; NS—no specification; Metros—Delhi, Kolkata, Mumbai, and Chennai. Unless otherwise specified, the years indicate when changes in fuel quality were implemented country-wide. The changes may have been implemented in notified areas previously (for example, gasoline with 0.15 and 0.013 g/L lead content was implemented in the above four cities in 1994 and 1995, respectively). See the sources for details regarding test procedures and other details. Sources: Bureau of Indian Standards (1995a, b, 2000a, b); Tata Energy Research Institute (2002).

Table 2. Indian Fuel Quality

Another important issue in the Indian context is that of gasoline evaporative emissions. There are no evaporative controls on the fuel distribution system, or on vehicles except cars produced from 1996. Indian gasolines have a high volatility, and the vast majority of gasoline vehicles are carburetted, not fuel-injected. These facts, along with India's high ambient temperatures, heighten the potential for evaporative emissions rich in reactive hydrocarbons, which participate in the formation of ground-level ozone.

The effects of vehicle technology and fuel quality have been exacerbated by in-use operating conditions. Congestion has increased rapidly in Indian cities, because of inadequate road infrastructure, modal separation, transport system management and traffic control. In Delhi, for example, the average speed for motorized passenger vehicles ranged from 12 to 20 km/hr in the 1990s. Besides causing time and productivity losses, congestion can increase fuel consumption, and carbon monoxide and hydrocarbon emissions per vehicle-kilometer, by 200% or more.

Fuel and lubricating oil adulteration has also been an important contributory factor. M3W vehicle operators, who typically do not own their vehicles, commonly adulterate gasoline with as much as 30% kerosene and even solvents. To guard against the resulting wear and tear, they mix as much as 10% of lubricating oil, the principal source of particulates in two-stroke engines. This adulteration has been enabled principally by the fact that kerosene, which is the poor persons! Cooking fuel, has been heavily subsidized and is 7–10 times cheaper than gasoline. Diesel is adulterated with kerosene also, though the diesel-kerosene price differential is lower than for gasoline-kerosene. Diesel is of concern because it accounts for a significant share of petroleum product consumption and imports, and diesel exhaust contains particulates that are predominantly in the fine particulate range, and many toxic air contaminants.

Fig 5. Air pollution by vehicular emissions

Construction

Construction activities emit particles during various activities including block cutting, excavation, demolition, mixing, road building, drilling, loading and unloading of debris etc. In addition, movement of vehicles (especially trucks) in and around construction sites increases the amount of particles by crushing and pulverizing the particles on the road surface. Several studies have highlighted the importance of construction as a PM source, though in receptor modelling studies, the source is combined with sources such as road dust. For six cities, construction accounted for up to 10% of the annual emissions.

Road Dust

Dust is a major concern for many cities in India (Figure 2) and comprises of particles emitted due to wear and tear of tyres and brakes and materials from the roads, pavements, and street furniture. Dust loadings increase even further in case the roads are not paved

Traditionally, all the streets, sidewalks and public areas are swept manually and depending on the resources, poor or marginal areas receive reduced or inadequate service, or no service at all, while wealthier, commercial, or tourist areas receive extensive service. However, often in manual street sweeping, most of the dust swept is left on the side of the roads, which gets re-entrained when the vehicle movement resumes during the day.

Power Shortages and Diesel Generators

In 2011, the peak electricity demand was approximately 122 GW and the peak electricity supply was approximately 110 GW. The gap between the supply and the demand crucial to understand India's power generation sector. In India, a third of the population in rural areas do not have access to electricity and those areas on the grid are not assured of uninterrupted supply. The blackout in July, 2012, that paralyzed 600 million people in 22 states in the Northern, Eastern, and North-eastern India, is testament to how tenuous power situation in the country.

In the urban areas, power cuts are severe in the winter and the summer months, when heaters and air conditioners are in full service, respectively. These needs are usually supplemented by in-situ large, medium, and small diesel generator (DG) sets at hotels, hospitals, malls, markets, large institutions, apartment complexes, cinemas, and farm houses and form an additional source of air pollution to an already deteriorating air quality in the cities. Telecommunication towers stand out, which with more than 500 million mobile phones in the country, are heavily dependent on DG sets. According to the Telecom Regulatory Authority of India (TRAI), 310,000 towers consumed over 2 billion litres of diesel in 2010 (TRAI, 2011). The mobile subscriber base is expected to reach 800 million by the end of 2013 with an additional 100,000 telecom towers in service.

For Chennai, Pune, Indore, Ahmedabad, Surat, and Rajkot, up to 10% of the modeled PM10 concentrations were found to originate from diesel generator sets (Guttikunda and Jawahar, 2012). In case of Delhi, the contribution went up to 15% (Guttikunda and Calori, 2013; Guttikunda and Goel, 2013). The use of generator sets is even higher in the rural areas, where they are mostly utilized for the pumping water in the agricultural lands.

Open Waste Burning

There is no reliable national-level data on the technical or financial aspects of solid waste management, and figures are therefore approximations. The country's annual generation of municipal solid waste is in the range of 35 to 45 million tons; likely to quadruple by 2030 at which time, the waste generation will be over 150 million tons a year (World-Bank, 2006;Annepu, 2012). The scale is perhaps more comprehensible at the city level - the national capital region of Delhi generates 10,000 tons/day and Mumbai 7000 tons/day. The waste collection efficiency in the cities is 50-90%, depending on the commercial and residential activities in various parts of the city. The waste not collected is eventually burnt.

The open waste burning problems are particularly worse in the medium and small scale cities, with very limited or no waste collection and no landfill facilities. Emissions of criteria pollutants from garbage burning are hard to quantify and are accompanied by large uncertainty. The toxic chemicals released during burning of paper, plastic, and biomass includes NOx, SO2, volatile organic chemicals (VOCs), and dioxins.

Fig 6. Burning of garbage in open.

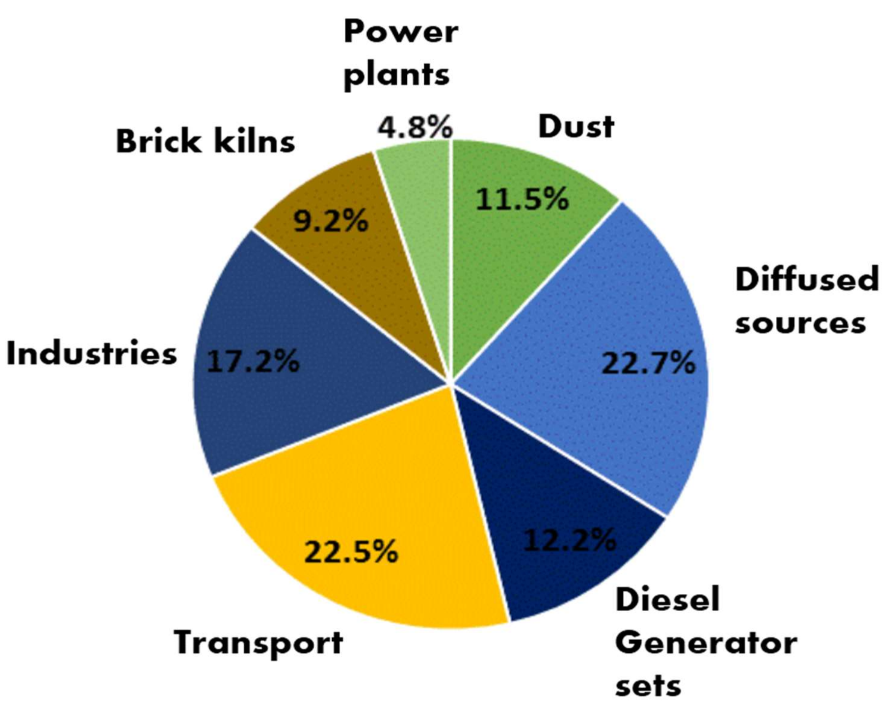


Fig 7. Pie chart showing different sources of air pollution in India

Impact of Air Pollution in India

Air pollution, both indoor (household) and outdoor, has had a significant impact on the health of citizens as well as the economy. The adverse effects of air pollution are not just restricted to the urban areas but also impact rural areas, where a majority of the population relies on kerosene and burning of biomass for lighting and cooking purposes respectively.

Air pollution is among the leading causes of death in India

The Global Burden of Disease Report has ranked outdoor air pollution as the fifth leading cause of death in India and indoor air pollution as the third leading cause. Outdoor air pollution was responsible for 6,20,000 deaths in 2010, increasing six-fold from 1,00,000 deaths in 2000. Moreover, a research study by researchers at the University of Chicago, Harvard and Yale estimated that high Particulate Matter (PM) concentration is responsible for reducing the life expectancy by 3.2 years for 660 million Indians living in urban conglomerates.

India has one of the highest annual average ambient particulate matter PM2·5 exposure levels in the world. In 2017, no state in India had an annual population-weighted ambient particulate matter mean PM2·5 less than the WHO recommended level of 10 μg/m³,45 and 77% of India's population was exposed to mean PM2·5more than 40 μg/m³, which is the recommended limit set by the National Ambient Air Quality Standards of India. Although the use of solid fuels for cooking has been declining in India,25,26 56% of India's population was still exposed to household air pollution from solid fuels in 2017. Behind these high overall air pollution exposure levels in India, there is a marked variation between the states, with a 12 times difference for ambient particulate matter pollution and 43 times difference for household air pollution. The low SDI states in north India had some of the highest levels of both ambient particulate matter and household air pollution, especially Bihar, Uttar Pradesh, Rajasthan, and Jharkhand; and the middle and high SDI states Delhi, Haryana, and Punjab in north India had some of the highest ambient particulate matter pollution exposure in the country.

India had 18% of the global population in 2017, but had 26% of global DALYs attributable to air pollution. A substantial 8% of the total disease burden in India and 11% of premature deaths in people younger than 70 years could be

	Death rate per 100 000 population attributable to air pollution (95% UI)	Number of deaths attributable to air pollution (95% UI)	Percentage of total deaths attributable to air pollution that were in people younger than 70 years (95% UI)	Number of deaths attributable to ambient particulate matter pollution (95% UI)	Number of deaths attributable to household air pollution (95% UI)
India	**89·9 (78·7–100·4)**	**1 240 530 (1 086 200–1 385 930)**	**51·4 (49·1–54·1)**	**673 129 (551 832–793 262)**	**481 738 (393 810–580 207)**
Low SDI states	**95·4 (81·5–108·3)**	**643 872 (549 996–731 115)**	**53·5 (51·1–56·7)**	**340 190 (263 550–416 005)**	**258 287 (205 354–324 027)**
Bihar	79·0 (68·5–89·3)	96 967 (84 078–109 709)	57·0 (54·0–60·3)	53 634 (34 033–71 587)	37 824 (25 054–53 047)
Madhya Pradesh	97·0 (83·8–111·6)	83 045 (71 698–95 520)	50·0 (47·0–53·1)	37 745 (26 975–52 117)	39 895 (28 515–51 405)
Jharkhand	69·0 (60·1–78·1)	26 486 (23 080–29 956)	59·2 (56·5–62·1)	12 053 (8629–16 445)	12 768 (9280–16 397)
Uttar Pradesh	111·1 (87·0–131·0)	260 028 (203 701–306 568)	53·1 (50·4–56·8)	161 178 (111 757–213 041)	78 888 (50 625–113 260)
Rajasthan	112·5 (88·6–132·8)	90 499 (71 340–106 868)	50·9 (47·9–55·3)	43 295 (28 068–59 617)	39 288 (27 444–52 551)
Chhattisgarh	98·9 (86·5–111·9)	29 841 (26 102–33 768)	57·8 (54·9–60·7)	11 144 (7844–14 823)	17 028 (13 231–21 093)
Odisha	65·3 (54·6–80·6)	31 118 (26 035–38 400)	54·9 (51·0–58·5)	11 985 (8004–16 865)	17 633 (13 486–22 464)
Assam	72·3 (62·3–82·2)	25 888 (22 282–29 426)	53·1 (50·0–56·6)	9156 (6748–12 050)	14 962 (12 114–18 319)
Middle SDI states	**86·7 (76·3–97·7)**	**336 235 (295 958–378 769)**	**50·2 (47·8–52·9)**	**173 401 (140 417–209 827)**	**139 053 (111 735–167 916)**
Andhra Pradesh	83·7 (65·5–105·2)	45 525 (35 629–57 235)	48·7 (45·5–52·1)	23 280 (17 188–31 262)	19 345 (13 519–25 999)
West Bengal	93·3 (81·4–106·6)	94 534 (82 494–108 038)	50·9 (48·1–53·9)	49 882 (38 014–61 616)	38 846 (29 193–49 869)
Tripura	91·1 (76·3–106·3)	3711 (3107–4329)	49·5 (45·9–53·7)	1627 (1236–2090)	1842 (1410–2331)
Arunachal Pradesh	36·0 (28·9–45·4)	608 (488–766)	50·0 (46·4–54·1)	197 (124–282)	363 (270–473)
Meghalaya	42·7 (34·3–51·7)	1440 (1157–1742)	54·8 (51·2–59·0)	520 (378–694)	847 (629–1091)
Karnataka	94·8 (79·9–109·9)	64 333 (54 254–74 645)	49·9 (47·0–52·9)	26 311 (17 415–36 597)	33 697 (25 528–42 243)
Telangana	65·8 (51·6–81·7)	26 000 (20 400–32 271)	50·4 (47·4–53·5)	15 239 (11 355–20 095)	8789 (5940–12 008)
Gujarat	84·9 (70·0–99·2)	58 696 (48 429–68 625)	49·3 (46·4–52·5)	29 791 (20 117–41 188)	24 169 (17 239–31 012)
Manipur	57·2 (46·4–69·8)	1949 (1583–2380)	50·0 (46·7–53·6)	944 (678–1269)	908 (671–1208)
Jammu and Kashmir	75·4 (61·7–88·3)	10 476 (8579–12 265)	45·8 (43·1–48·8)	5822 (4157–7681)	3496 (2459–4680)
Haryana	100·1 (84·5–116·6)	28 965 (24 456–33 749)	54·3 (51·9–57·1)	19 788 (14 268–25 114)	6751 (4230–10 120)
High SDI states	**81·9 (72·9–91·5)**	**260 421 (231 677–290 889)**	**47·5 (44·9–50·0)**	**159 538 (132 798–188 666)**	**84 398 (67 746–104 058)**
Uttarakhand	106·4 (88·0–125·9)	12 000 (9917–14 190)	44·7 (42·1–47·8)	6959 (4524–9575)	3570 (2260–5185)
Tamil Nadu	75·9 (63·6–90·2)	61 205 (51 249–72 725)	53·0 (50·0–56·1)	39 860 (28 617–54 082)	19 625 (13 916–25 680)
Mizoram	52·9 (42·4–64·7)	652 (522–797)	46·0 (43·1–49·6)	339 (242–446)	243 (176–317)
Maharashtra	86·9 (74·7–99·2)	108 038 (92 977–123 398)	44·3 (41·6–47·1)	62 677 (48 480–77 981)	36 932 (26 928–47 989)
Punjab	86·3 (75·5–97·1)	26 594 (23 259–29 896)	58·1 (55·5–60·7)	19 178 (15 170–23 383)	6139 (4128–8543)
Sikkim	61·5 (48·2–75·2)	413 (323–505)	43·5 (40·8–46·8)	243 (170–319)	131 (89–184)
Nagaland	48·8 (38·8–60·5)	958 (762–1188)	50·5 (46·9–54·4)	427 (315–562)	494 (359–661)
Himachal Pradesh	99·7 (80·2–119·1)	7485 (6022–8937)	40·9 (38·2–44·1)	3307 (2073–4602)	2986 (2080–4046)
Union territories other than Delhi	48·5 (36·3–65·0)	1812 (1356–2425)	52·0 (48·6–55·7)	1362 (886–1973)	340 (226–485)
Kerala	79·3 (68·2–91·3)	28 051 (24 130–32 278)	38·6 (35·3–42·0)	12 754 (10 003–16 224)	13 758 (10 834–16 961)
Delhi	65·3 (54·4–76·9)	12 322 (10 264–14 498)	51·1 (48·7–53·5)	11 732 (9705–13 882)	52 (27–93)
Goa	58·2 (46·9–73·7)	892 (719–1130)	42·5 (39·1–45·8)	700 (539–914)	129 (85–184)

SDI=Socio-demographic Index. UI=uncertainty interval.

Table 2: **Deaths attributable to air pollution, ambient particulate matter pollution, and household air pollution in the states of India, 2017**

attributed to air pollution. We estimated that 1·24 million deaths in India in 2017 could be attributed to air pollution, including 0·67 million to ambient particulate matter pollution and 0·48 million to household air pollution. Furthermore, a report has suggested that there are additional diseases attributable to air pollution that are currently not being included in the estimates of deaths attributable to air pollution in GBD, leading to underestimation of the health impact of air pollution.

Negative impact on agricultural productivity

A recent research study "Recent climate and air pollution impacts on Indian agriculture" by scientists at the University of California, San Diego suggests the adverse impact of air pollution caused by Short-Lived Climate Pollutants (SLCPs) on agricultural productivity. They observed that the yield of wheat in 2010 has reduced by almost 36% and that of rice by 20% when compared to figures from 1980, negating for climate change. SLCPs such as ozone and black carbon are released into the atmosphere by motor vehicle exhausts and rural cook stoves respectively. These SLCPs remain in the atmosphere for short periods.

Cost of Air pollution amounts to 3% of the GDP

A World Bank report titled 'Diagnostic Assessment of Select Environmental Challenges in India" highlighted that the annual cost of air pollution, specifically pollution from particulate matter (burning of fossil fuels) amounts to 3% of the GDP of the country; outdoor air pollution accounting for 1.7% and indoor air pollution for 1.3%. The report also observed that a 30% reduction in particulate emissions by 2030 would save India $105 billion in health-related costs; a 10% reduction would save $24 billion.

In light of the adverse impacts, coupled with the fact that the concentration of particulate matter in 180 Indian cities is almost six times higher than the standards set by the WHO, the issue of quality of air has become a major concern for the government of India.

Control Measures to tackle Air Pollution

Amid growing concerns pertaining to rising air pollution, government of India has taken various initiatives as well as introduced policies to address the issue. In order to prevent and control air pollution, the Parliament of India enacted the Air (Prevention and Control of Pollution) Act, 1981 on 29th March 1981, which came into force on the 15th May of the same year. The Central Pollution Control Board (CPCB), a statutory organization under the Ministry of Environment & Forests (MoEF) has been entrusted with the responsibility of ensuring ambient air quality and has been conferred and assigned the power and functions to achieve the stipulated objective. Thereby, the CPCB in association with various State Pollution Control Boards (SPCBs) monitors the ambient air quality according to the National Ambient Air Quality Standards (NAAQS) with the help of 580 manual stations established in 244 cities, towns and industrial areas.

I) Steps to curb vehicular emission

With the increase in number of vehicles on Indian roads, air pollution resulting from vehicular emissions has become the main source of air pollution in the urban centres of the country. Moreover, in FY 2014, the share of diesel cars in overall car sales was 53%. According to a report released by the International Council on Clean Transportation, diesel vehicles are responsible for 56% of all PM emissions and 70% of all Nitrogen Oxides (NOx) emissions from on-road vehicles in India. Moreover, the content of sulphur in fuel makes it dirtier and lowers the efficiency of catalytic convertors, which control emissions in automobiles. Therefore, several steps have been taken to mitigate the issue of vehicular emissions.

- ### Adopting emission norms and fuel regulating standards

Since the year 2000, India started adopting European emission and fuel regulations for all categories of vehicles. Under this plan, the Bharat Stage II emission standards were introduced initially in the four metro cities to manage the amount of air pollutants released by the internal combustion engine's equipment by using cleaner fuel with low sulphur content and improved combustion engines. Accordingly, oil marketing companies were required to supply BS compliant fuel and auto manufacturers had to upgrade engines in a phased manner. Later on, the Bharat Stage fuel norms were applied to the rest of the country; as of 26th November 2011, BS – IV norms are applicable in 34 cities whereas BS –III norms are applicable in the rest of the country. However, India has been following European norms with a time lag of five years and it is infact a decade behind developing countries such as Turkey and Brazil in introducing cleaner-burning fuel. The Saumitra Chaudhari Committee, formed to look into automobile fuel emission standards, has recommended that the government introduce the Bharat Stage – V norms across the country by 2020.

- **Promotion of cleaner technologies and alternate sources of energy to run vehicles**

National Mission for Electricity Mobility (NMEM) is aimed at enhancing penetration of efficient and environmentally friendly hybrid and electric vehicles; GoI earmarked 1,000 crores for the Plan in 2015 with an eye to decrease CO2 emissions by 1.2-1.5% in 2020.

Promotion of the cultivation, production and use of biofuels to substitute petrol and diesel in automobiles. Indicative target of 20% blending of bio-fuels such as bio-diesel and bio-ethanol by 2017 is proposed; Ethanol run bus launched in Nagpur under 'Green Bus' Project.

- **National Urban Transport Policy:** *Encouraging greater use of public transport in urban areas*

Most Indian cities are increasingly relying on motorized personal transport; in cities like Pune & Ahmedabad, motorized personal transport (in the form of cars and two-wheelers) accounts for a 48% and 44% share in the modes of transport used, respectively. With this in mind, the National Urban Transport Policy launched in 2006 by the Ministry of Urban Development (MoUD) and reviewed in 2014 seeks to prioritize the use of public transport running on cleaner fuel and technology and develop a people-centric sustainable multi-modal urban transport network, taking into consideration the unique characteristics and specific situations prevalent in cities. Therefore, various cities have either adopted or are in the process of developing public transport systems such as Mass Rapid Transit Systems (MRTS), Light Rail Transit System *(*LRTS) & Bus Rapid Transit Systems (BRTS); currently 14 MRTS, 8 BRTS are operational in India.

II) Reducing the dependence on biomass burning in rural households

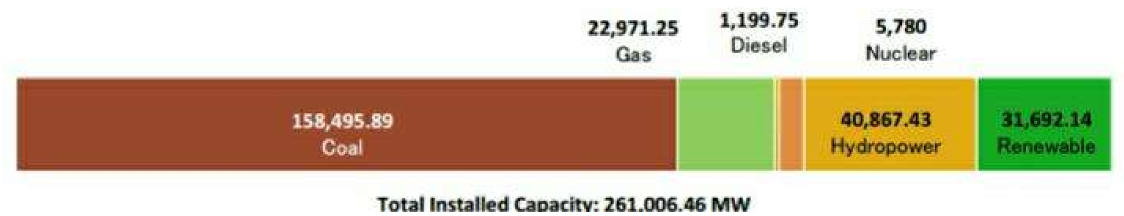
Biomass – fuel wood, agricultural residue and animal waste – is among the most prevalent sources of energy in India, with almost 87% of rural households and 26% of urban households dependent on biomass for cooking. These fuels are burned in outdated cook stoves as a result of which they emit harmful pollutants, contributing to indoor air pollution in rural areas. The Government of India has focused on the importance of clean and efficient cook stoves in order to reduce emissions as well as the health hazards associated with inhalation of these emissions.

- **National Biomass Cookstoves Programme:** ***i****mproved cookstoves to reduce indoor air pollution*

The National Biomass Cookstoves Programme (NBCP) was launched by the Ministry of New and Renewable Energy to promote the use of improved cookstoves, which would result in reduced emissions and offer cleaner cooking energy solutions. As part of this programme, the government undertook wide consultations with NGOs, entrepreneurs and industries in the country with the objective of identifying ways and means for the development and deployment of improved biomass cook stoves across a large number of community undertakings and individual households.

Based on further discussions and deliberations, the government initiated the National Biomass Cookstoves Initiative to design, develop an efficient and cost-effective device and assess the status of improved chulhas. Under this initiative, pilot scale demonstrative projects were undertaken to test for the efficiency of community-size cook stoves in Mid-day meal schemes in government schools in states of AP, Chhattisgarh, UP, Maharashtra, MP and Haryana and individual biomass cook stoves in J&K, Bihar, Karnataka, UP and Jharkhand. The results of the projects indicated substantial reduction in emissions and fuel consumption Accordingly, the Unnat Chulha Abhiyan has been launched to expand the deployment of the improved cook-stoves across the country. Rs.131 crores have been allocated for promotion of improved cookstoves and solar cookers in the Union Budget 2015-16.

III) Renewable Energy – the new area of focus to reduce dependency on coal



India is extremely rich in renewable energy (RE) sources, such as wind, solar and small hydro, however, green energy accounts for only 12.14% of India's total installed power capacity. According to the India Renewable Energy Status Report 2014, the total renewable energy potential from various sources in India is 2,49,188 Mw which implies that only 12.71% of the potential has been achieved. Moreover, wind energy constitutes almost 65% of the total renewable energy generated in the country. It is imperative that the country alters its existing energy mix and reduce its reliance on coal and shift to greener modes of energy. The Electricity Act, 2003 proposed mandatory Renewable Purchase Specifications (RPS) for all states in order to increase the uptake of electricity from renewable energy sources.26 State Electricity Regulatory Commission (SERC) specified the mandatory purchase obligation for purchase of fixed percentage of energy generated from RE sources. It is in line with this idea that the government has set an ambitious target to achieve 175,000 MW of green energy by 2022 including one lakh MW of solar power, 60,000 MW of wind energy, 10,000 MW of biomass and 5000 MW of small hydro projects. Accordingly, several incentives and policy initiatives at the Central and State levels have been put in place both for grid connected and off-grid renewable energy

- **Solar Power:** *to become a crucial component of India's power portfolio*

The Jawaharlal Nehru National Solar Mission (JNNSM), part of the missions launched as part of the National Action Plan on Climate Change seeks to tap the immense potential of solar power as a future energy source in the country. As part of the mission, it is envisaged that the installed capacity of solar power – both solar thermal and solar photovoltaic should be ramped up to 20 GW by 2022 in three phases; in order to achieve the same, an enabling policy framework for manufacturing solar components and setting up power plants should be created. Furthermore, off-grid applications are to be promoted and steps taken to bring tariff to grid parity level. This mission has been largely successful and the current government has revised the target to 100 GW by 2022. Currently, the second phase of the Solar Mission is underway and the total installed capacity of solar power stands at 3,382.78 MW.

Move from carbon subsidization to carbon taxation

Cess on coal has been doubled to Rs. 200 per tonne from Rs. 100 per tonne, which will boost renewable energy financing. India is among the few countries in the world to have introduced such a tax. The cess is collected as National Clean Energy Fund and is disbursed for renewable energy-based initiatives and power projects.

IV) National 'Air Quality Index' to enable common man to understand Air Quality

Announced in October 2014 by the Ministry of Environment, Forests and Climate Change, the National Air Quality Index (AQI) is a measurement index consisting of 8 parameters, which would disseminate information in a simple and effective manner to the common man as characterized by its slogan "One Color, One Number and One Description". This data would be available for 10 cities in the first phase after the launch and would be disseminated in a real-time manner to enhance public awareness. Under the AQI scheme, the levels of the 8 pollutants are categorized as Good, Satisfactory, Moderately Polluted, Poor, Very Poor and Severe based on the ambient concentration, conformity to National Ambient Air Quality Standards and likely health impact. It is planned that this air quality index would be extended to 20 state capitals and 46 million plus cities over the next couple of years. This was launched by the Prime Minister on the 6thApril, 2015.

Conclusion

Air Pollution is a complicated issue and negatively impacts the health of citizens as well as the economy of the country. Both indoor and outdoor air pollution have emerged as one of the leading causes of deaths in India and while recent reports highlight the worsening outdoor air pollution in urban centres, indoor air pollution due to biomass burning and inefficient 'chulhas' is also an area of concern. The Government of India and the state governments have recognized the adverse effect of air pollution and there is increased seriousness about addressing the air quality issue among all the stakeholders.

Electrostatic precipitators have been added to chimneys of industries to prevent emission of particulate matters in the environment. We should also seriously consider alternative energy and renewable energy use to reduce pollution. Using respiratory mask should be encouraged among traffic cops and others who get regularly exposed to toxic air contaminants.

Ground measurements, computational studies, and satellite measurements, are all pointing towards changing pollution trends in India. Today, India has the unique opportunity to further the air pollution abatement measures at the urban and the regional scale, but these depend on effective inter-sector and inter-ministerial collaboration. This is primarily due to the fact that all the sources contributing to the air pollution are interlinked. Among the sectors, transportation is the most critical and most connected.

Following the review, two challenges have emerged for better air quality in the Indian cities (a) the need to secure greater public awareness of the problems and commitment to action at civic, commercial, and political levels (b) to ensure that action to tackle air pollution is seen in the context of wider social and economic development policies. For example, how much cities these interventions help reduce the local challenges, like providing safer and reliable public transportation systems; cleaner and efficient waste management; dust free roads; and pollution free industries and power plants.

Furthermore, recent efforts such as the launch of National Air Quality Index point to the need for enhancing public awareness on the quality of air they are breathing. A shift towards renewable energy is part of the plan to reduce dependency on fossil fuels as well as provide clean energy to households, which are currently using kerosene for lighting purposes. It is important that a comprehensive, integrated and long-term plan of action, involving coordination between different ministries and departments, is drawn to address the issue, reduce air pollution and ensure that citizens breathe clean air.

Reference

- Guttikunda, S.K, Goel, R., Pant, P., Nature of Air Pollution, Emission Sources, and Management in the Indian Cities, Atmospheric Environment (2014)
- MADHAV G. BADAMI
  School of Urban Planning and McGill School of Environment, McGill University Macdonald-Harrington Building 815 Sherbrooke Street West .Montreal, Quebec, Canada H3A 2K6
- https://www.researchgate.net/publication/283072534
- https://www.researchgate.net/publication/330483317
- Jennifer Burneya,1 and V. Ramanathanb

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