What Pollutes India?

Understanding the PM2.5 Inventory

Chandra Bhushan

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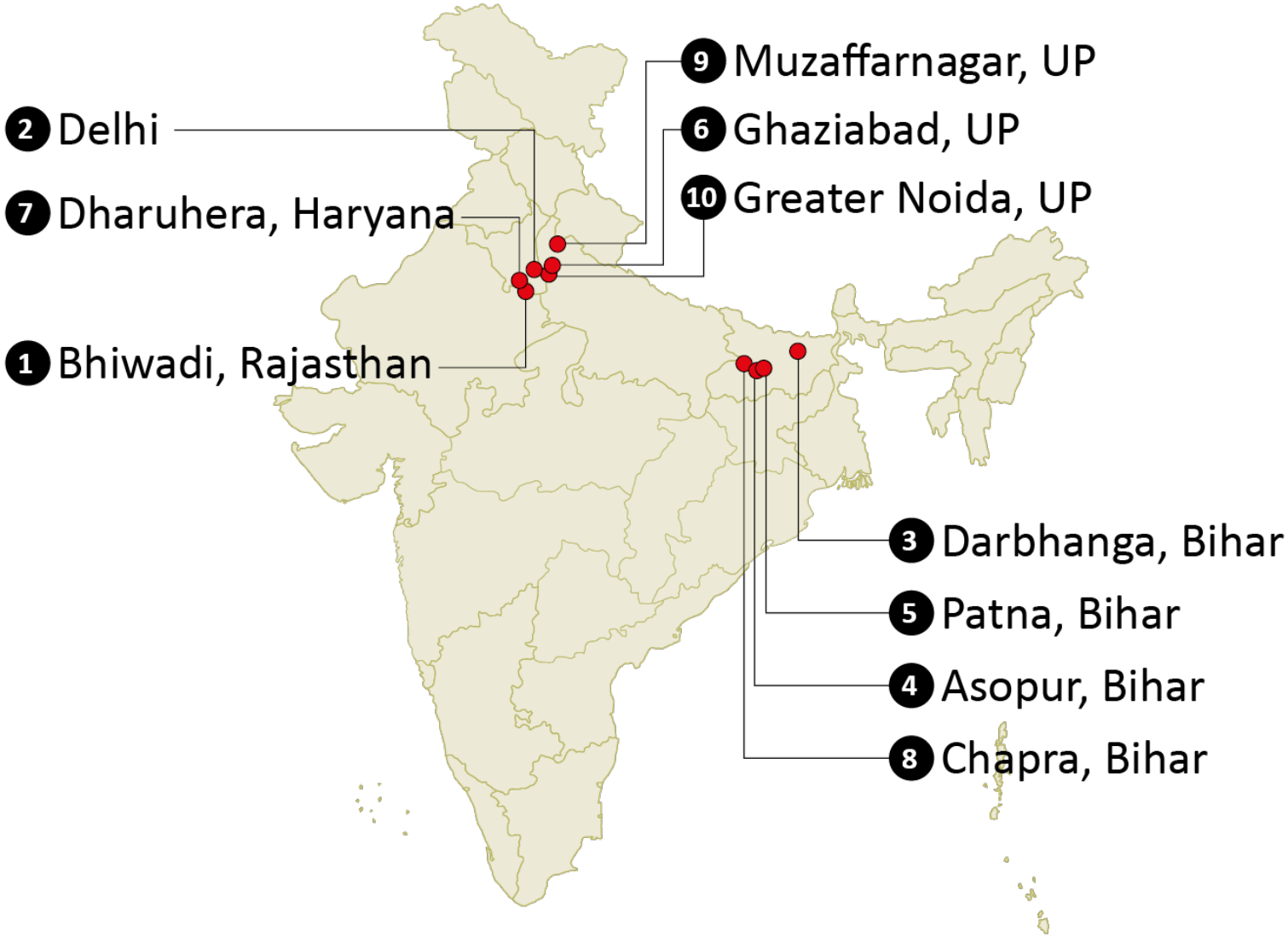
List of most polluted cities in India in 2022 based on PM2.5



Source: IQAir

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Air Pollution is equally bad in Rural India

> Proc Natl Acad Sci U S A. 2020 Nov 17;117(46):28640-28644. doi: 10.1073/pnas.2007236117. Epub 2020 Nov 2.

Outdoor air pollution in India is not only an urban problem

A R Ravishankara [1] [2], Liji M David [3] [2], Jeffrey R Pierce [2], Chandra Venkataraman [4]

Affiliations + expand

PMID: 33139542 PMCID: PMC7682420 DOI: 10.1073/pnas.2007236117

Free PMC article

Abstract

Urban outdoor air pollution in the developing world, mostly due to particulate matter with diameters smaller than 2.5 μm ($PM_{2.5}$), has been highlighted in recent years. It leads to millions of premature deaths. Outdoor air pollution has also been viewed mostly as an urban problem. We use satellite-derived demarcations to parse India's population into urban and nonurban regions, which agrees with the census data. We also use the satellite-derived surface $PM_{2.5}$ levels to calculate the health impacts in the urban and nonurban regions. We show that outdoor air pollution is just as severe in nonurban regions as in the urban regions of India, with implications to monitoring, regulations, health, and policy.

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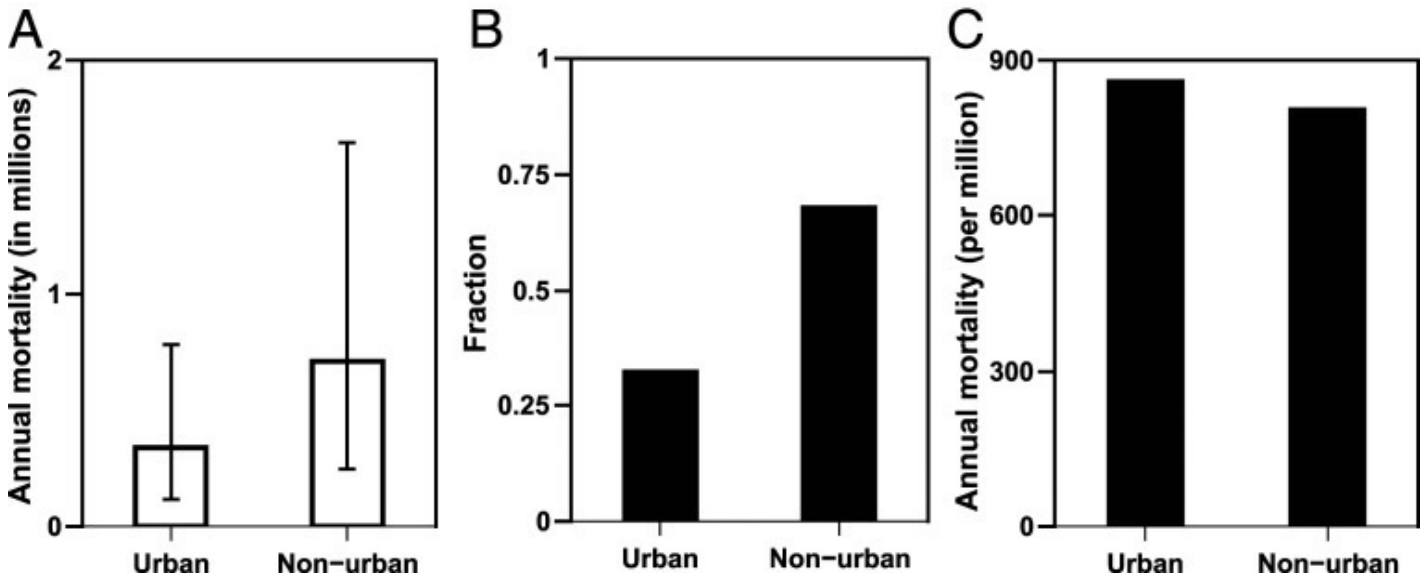

Annual Mortality due to PM2.5

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Air pollution in rural India: Analysis of satellite NO_2 measurements

Mansi Pathak and Jayanarayanan Kuttippurath
Indian Institute of Technology, Kharagpur, Centre of ocean, river, atmosphere and land sciences, Kharagpur, India
(r.mansipathak@kgpian.iitkgp.ac.in)

India is a country having more than 67% of its population (947 million) residing in rural areas as of 2020. Therefore, health of the people in rural India becomes important for development plans, economy and growth of the nation. As the sources of NO_2 are closely linked to the industrial and economic development of a country, we use satellite measurements of NO_2 in rural and urban areas of India to analyse the air quality in these areas. Our findings for rural areas show strong seasonal variations, with winter having the highest NO_2 (2.0×10^{15}molec./cm^2) whereas monsoon having the lowest (1.5×10^{15}molec./cm^2) levels. Around 40% of the total NO_2 pollution comes from rural sources with 45% of it attributed to road transport, however urban areas with more than 90% of their NO_2 from power sector were focused in the past studies. Our assessment shows that the NO_2 exposure in rural regions is as severe as in urban areas; indicating the need for more effective reduction measures of population exposure and protection of public health. Henceforth, this study reveals that rural India is gradually getting polluted from its nearby regions as well as from the new sources within, which is a big concern for the health of the large rural population of India.

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All-India Agenda

- More than 80% of the population breathes air that is worse than India's national standard.
- India's ambient air quality norms for healthy air is four times higher than WHO's standards.
- **Thus, almost all of the country breathes air that is considered unsafe by WHO.**

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PM2.5 Inventory of India

What we burning?

Emissions are amount of fuel/wastes multiplied by Emission Factors *(which is based on the type of fuel and the effect of control technologies)*.

	Million Tonnes	Pollution potential	Pollution Control Technologies
Coal	1,050	High	Yes in medium and large industry; None in domestic, micro & small
Residential biomass	350	Highest	None
Biomass - industry	150	Highest	Yes
Agro-residue	100	Highest	None
Oil in Road Transport	125	Moderate	Yes
Natural gas	50	Lowest	In Industry & Power plants
Open waste burning	10-15	Highest	None
Total	**1,840**		

Methodology

Stationary fuel combustion and industrial processes

- **Emissions from stationary fuel combustion and industrial processes are calculated using activity data and emission factors, including the effect of control technologies.**

$$E = \sum_i \sum_j \sum_{k,l} \{A_{i,j} \times F_{i,j,k,l} \times EF_{i,j,k} \times (1-R_{i,j,l})\}$$

** E represents emission, i is the type of activity data, j is the type of sector category, k is the type of technology related to emission factor, l stands for the control technology after emission, A is the amount of activity data, EF is the emission factor of each technology, R is the removal efficiency of each technology, and F is the fraction rate of activity data for a combination of i, j, k, and l.*

Methodology

Stationary fuel combustion and industrial processes

Atmos. Chem. Phys., 20, 12761–12793, 2020
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Atmospheric Chemistry and Physics
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Long-term historical trends in air pollutant emissions in Asia: Regional Emission inventory in ASia (REAS) version 3

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[1]Asia Center for Air Pollution Research, 1182 Sowa, Nishi-ku, Niigata, Niigata, 950-2144, Japan
[2]National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan

Limitations of Kurokawa et al.:

1. Data till 2015
2. Underestimation of the use of residential fuels, especially heating.
3. Have not consider emissions from the open burning of agricultural residue.

India-specific estimate for 2015 offered us a benchmark to gauge whether our own estimates for 2021 were within the range of expectation.

Methodology

Emissions from residential fuel

Data Source

- *NSS 58th Round for 2002 (select States and UTs) – Percentage & No. of HHs using different kinds of fuels for cooking and lighting.*
- *NSS 68th Round for 2010-11 – Percentage & No. of HHs using different kinds of fuels for cooking and lighting.*
- *NSS 78th Round for 2020-21 (All States and UTs) – Percentage of HHs using different kinds of fuels for cooking, **heating** and lighting.*

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PAPER

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Heating and lighting: understanding overlooked energy-consumption activities in the Indian residential sector

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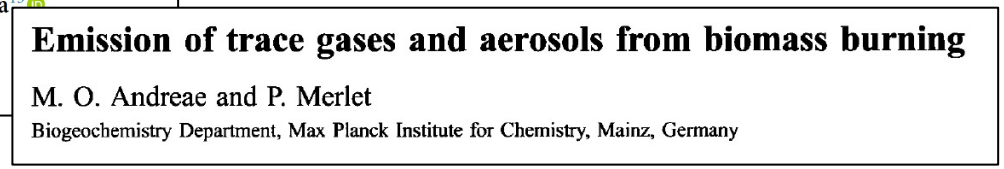

Emission of trace gases and aerosols from biomass burning

M. O. Andreae and P. Merlet
Biogeochemistry Department, Max Planck Institute for Chemistry, Mainz, Germany

Methodology

Emissions from open agro-residue burning

Data Source

- *Crop production - Directorate of Economics and Statistics, Department of Agriculture and Cooperation.*

Aerosol and Air Quality Research, 14: 422–430, 2014

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Emission of Air Pollutants from Crop Residue Burning in India

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Air quality impacts of crop residue burning in India and mitigation alternatives

Ruoyu Lan, Sebastian D. Eastham, Tianjia Liu, Leslie K. Norford & Steven R. H. Barrett

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Emission of trace gases and aerosols from biomass burning

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Methodology
Mobile sources

- **Emissions from mobile sources are calculated using vehicle type, number of vehicles in operation, annual distance travelled and emission factor.**

$$E = \sum_i \sum_j \sum_k (VP_{i,j,k} \times ADT_{i,j,k} \times EF_{i,j,k})$$

** E represents emission, 'I' is the vehicle type (two-wheeler, four-wheeler, three-wheeler, bus, HDV, and LDV); 'g' is the age group of vehicles on-road (till 2000, post-2000, post-2005, post-2010, and post 2015); 'k' is the fuel type (gasoline, diesel, and CNG), VP is the vehicle population of in-use vehicles (based on survival fraction), ADT is the annual average distance travelled and EF is the emission factor of air pollutants (PM2.5) depending on the vehicle type, age and fuel type.*

Methodology
Mobile sources

Data Source

- *Year-wise, category-wise number of registered vehicles – Road Transport Year book, Ministry of Road Transport and Highways.*
- *India emissions standard - IARI*

Estimating emissions from the Indian transport sector with on-road fleet composition and traffic volume

Apoorva Pandey [a], Chandra Venkataraman [a b]

Emissions inventory for road transport in India in 2020: Framework and post facto policy impact assessment

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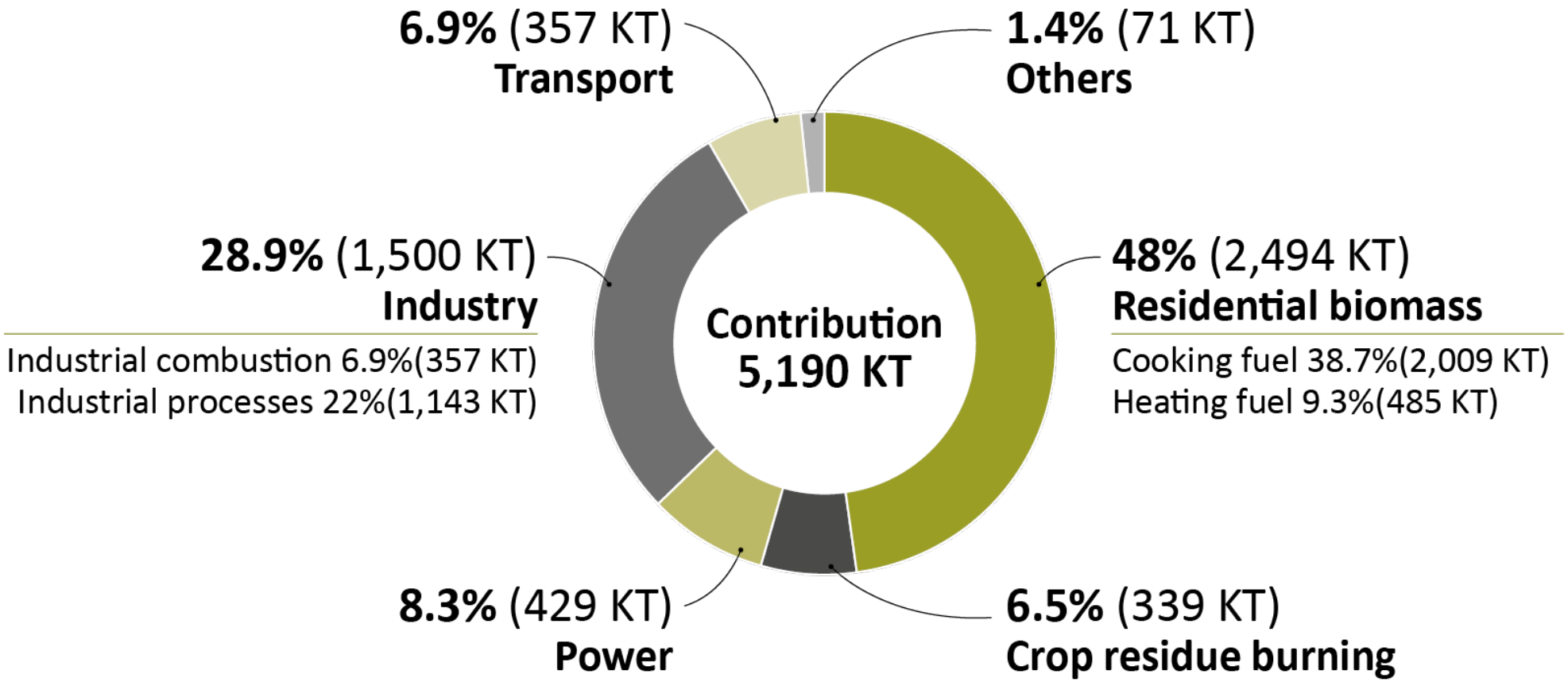
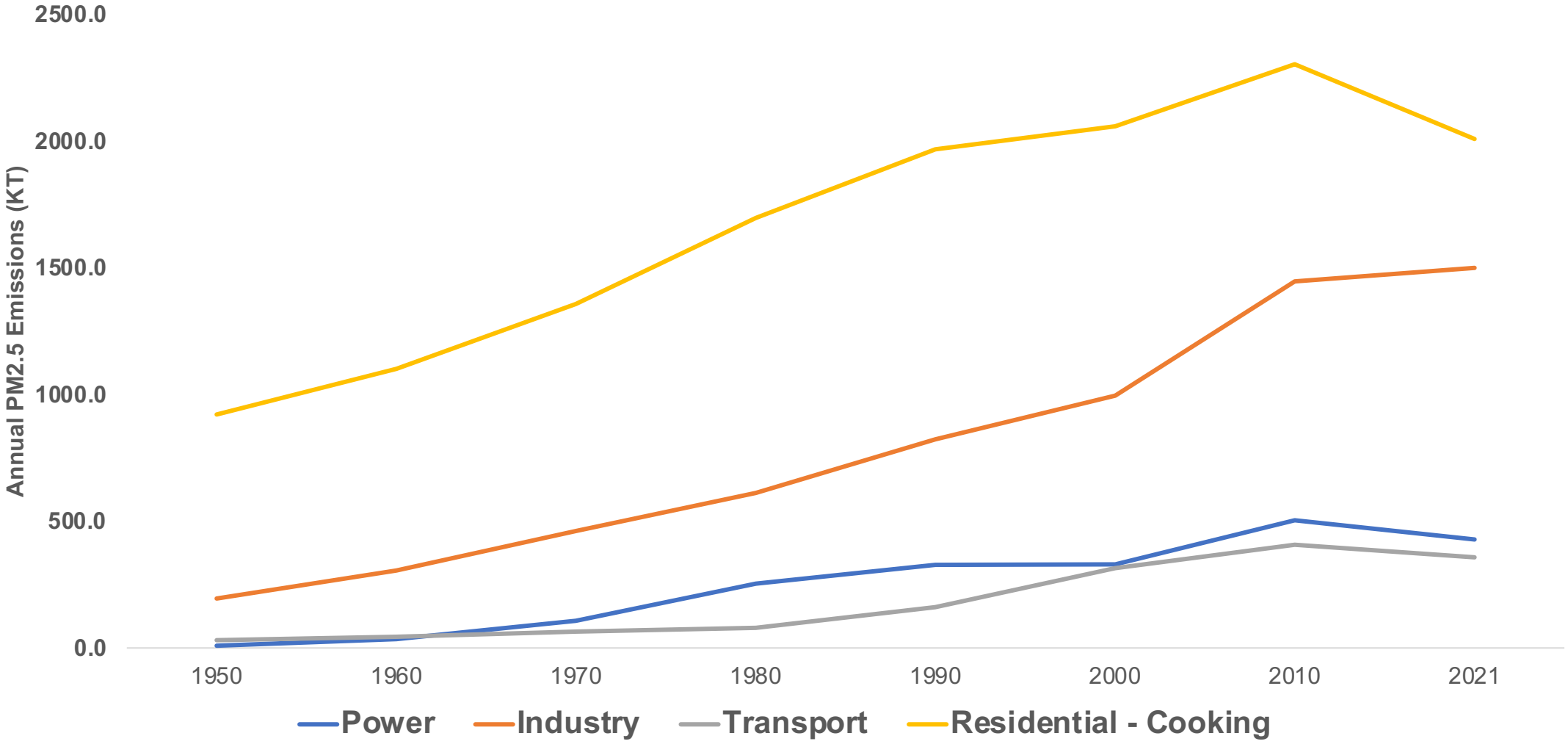
PM2.5 Inventory



Annual Emission in Kilo Tonnes

Trend in PM2.5 Emissions



Source: Kurokawa et al. – 1950 to 2010; iFOREST: 2021

Trend in Residential Cooking PM2.5 Emissions

	2000	2010	2021
No. HHs using biomass (millions)	150	160	110
Residential Cooking PM2.5 Emissions (KT)	2,059	2,304	2,009
Per Capita Emissions (Kg/capita)	1.9	1.9	1.4

Source: Kurokawa et al. – 2000 & 2010; iFOREST: 2021

Automobile Emissions

Study	Year	PM2.5 Emissions (KT)
Pandey & Venkataraman	2010	276
Kurokawa et al.	2015	428
Namita Singh et al.	2020	164
iFOREST	**2021**	**357**

Impact of crop-residue and heating fuel

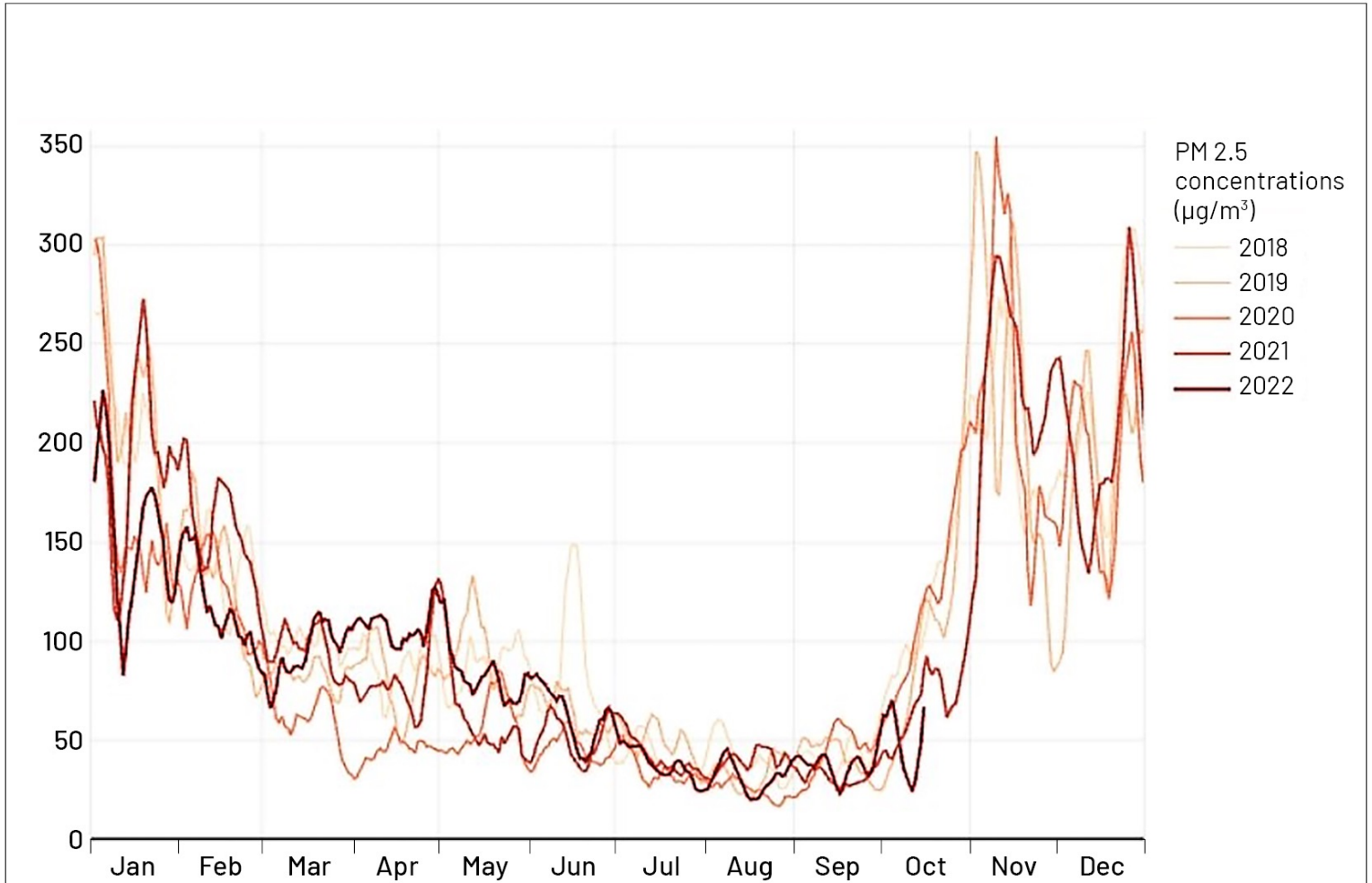
1. Crop-residue burning

Crop	% of total Crop-residue that is burnt	Months
Paddy	40%	Oct.-Nov.
Wheat	20%	April-May
Sugar Cane	20%	Nov.-Jan.
Rest	20%	Dec.-March

2. Heating Fuel

50% used during Winter (Dec, Jan & Feb).

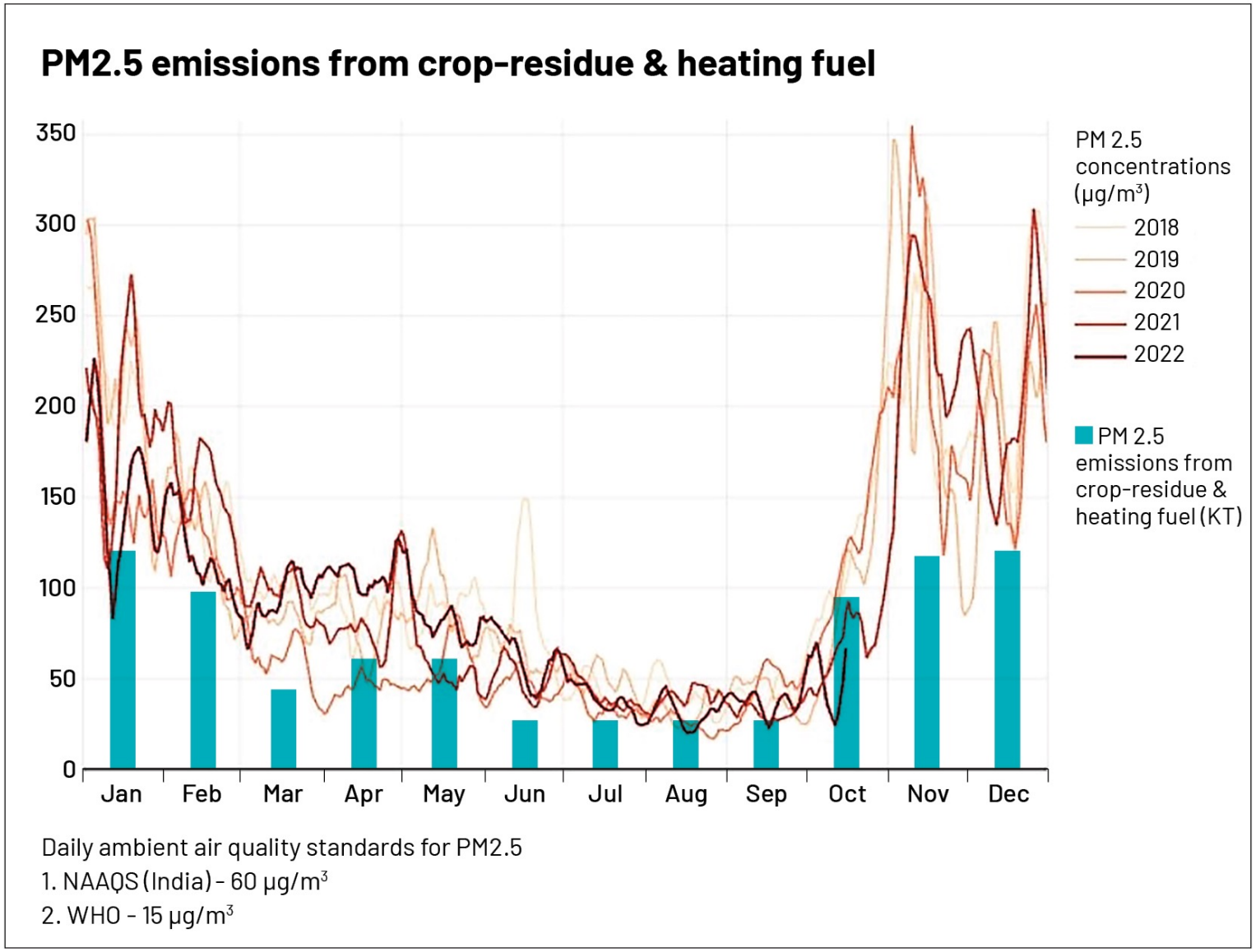
Impact of crop-residue and heating fuel



Daily ambient air quality standards for PM2.5

1. NAAQS (India) - 60 µg/m^3
2. WHO - 15 µg/m^3

Impact of crop-residue and heating fuel



Daily ambient air quality standards for PM2.5

1. NAAQS (India) - 60 µg/m^3
2. WHO - 15 µg/m^3

Recommendations

1. Focus on residential fuel

- Meet SDG goal of providing clean cooking fuel to all households by 2030
- Will require trebling the rate of proving clean cooking fuel -- from 5 million HHs between 2010-2020 to 15 million HHs between 2023-2030.
- Will avoid 800,000 pre-mature deaths each year from indoor air pollution
- Will be the most important action on ambient air pollution
- **A pro-poor agenda**

2. Eliminate crop-residue burning

- Immediate air quality benefit – reduce severe and hazardous days
- Modify combine harvesters
- Use incentives (Rs. 100/quintal) and disincentives (non-procurement under PDS)
- **A pro-farmer agenda to save soil, environment and farm sustainability.**

Recommendations

3. Reduce emissions from industries and power plants

- About 60% Power plants not meeting 2015 standards
- Compliance poor in SMEs
- Improve monitoring, compliance and enforcement
- Shift SMEs to cleaner fuel including electricity

4. Expedite the transition to green and shared mobility

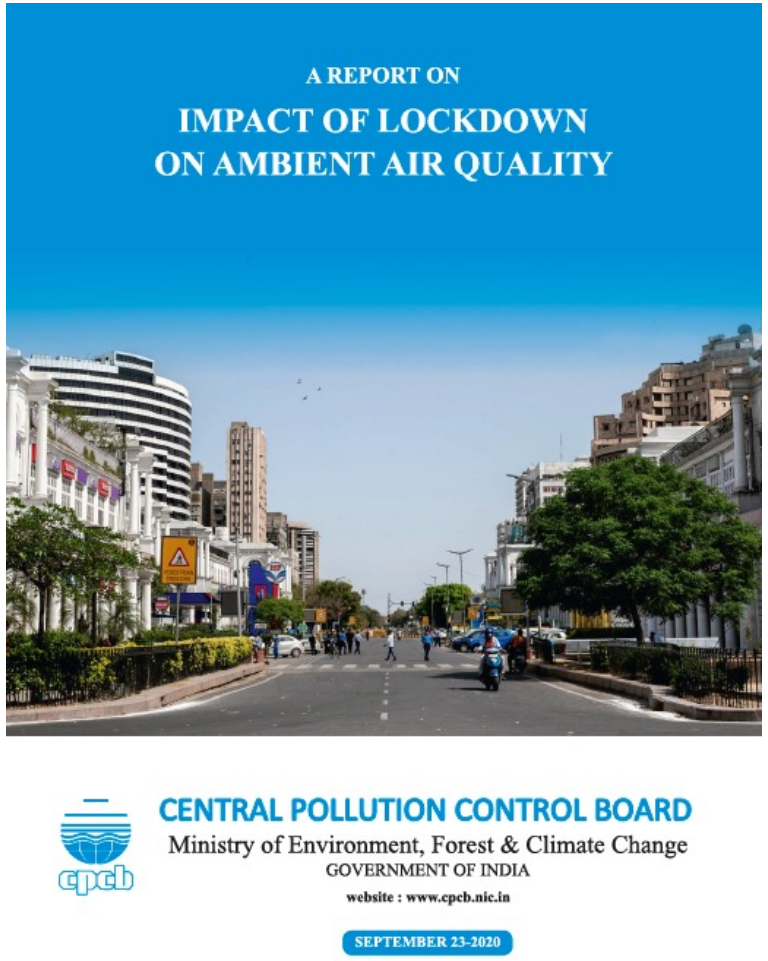
- Accelerate EV transition
- Promote public transport
- Promote walking and NMTs in cities

Key messages

1. Reduction in PM2.5 emissions is apparent in residential, road transport and power sector. But these are not sufficient make any significant improvements in the air quality.
2. City-based action plans -- National Clean Air Programme – will not delivered desired results. **The focus should be regional and should include rural areas.**
3. Reduction in open biomass burning is key to improving air quality.
4. Reduction in emissions from industry and power plants is equally important.

Question

If biomass is such a significant source of PM2.5 then why air was clean during COVID19?



Peak lockdown: March 25 – April 19, 2020 **(less polluting months in India)**

Status: Transportation and industry down by 80%; power plants operating at 40% CUF, no crop-residue burning.

Air Quality

- Ground-based monitoring of 12 cities:
  PM2.5 – 25-50 microgram/m^3
- Satellite based monitoring of PM2.5:
  All India average of 59 microgram/m^3 **– similar to NAAQS**

Question

If biomass is such a significant source of PM2.5 then why air quality was not so bad in the past?

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Long-term historical trends in air pollutant emissions in Asia: Regional Emission inventory in ASia (REAS) version 3

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[2]National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan

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