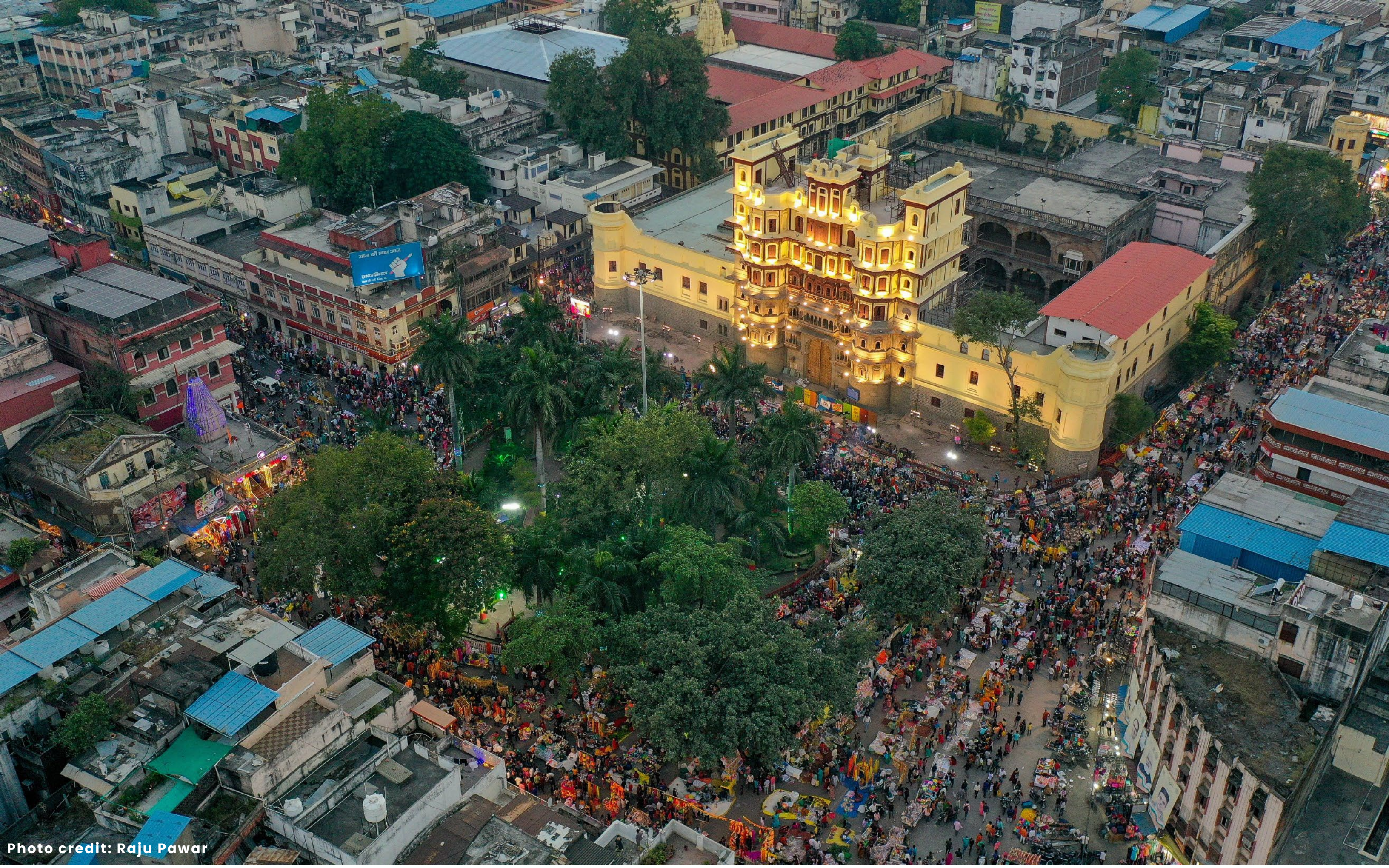
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CLEAN AIR CATALYST

Understanding Indore's Air

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Understanding Indore’s Air

Globally, 99% of people breathe air with levels of pollutants that exceed World Health Organization (WHO) air quality guidelines (WHO, 2022). Low- and middle-income nations bear the brunt of the burden, with the greatest toll on populations living in the WHO’s Western Pacific and South-East Asia regions. According to WHO’s database of polluted cities, released in April 2018, India accounted for 14 out of the top 15 cities for worst fine particulate matter pollution (PM2.5).

With a population of more than 3.4 million, Indore is the most populous city and the second largest city by area in the central Indian state of Madhya Pradesh and serves as a commercial and industrial hub for the state. Manufacturing and service industries are the main economic activities, with the industrial belt mostly concentrated at Pithampur to the southwest of the city and Sanwer to the north (Guttikunda & Jawahar, 2012).

Air pollution data available over the past five years from two manual sites in Indore suggests that PM2.5 concentrations exceed WHO annual average standard of 5 µg/m3 and are increasing. The PM2.5 annual averages measured in 2019 at the three manual monitoring sites in Indore (based on measurements made approximately every third day) are all between 36–39 µg/m3. The highest pollution is measured during the post-monsoon season (October–November) and during the winter months (December–February), due in part to lower wind speeds and shallower planetary boundary layer during these months.

The Clean Air Catalyst (CAC) is a five-year flagship program funded by the United States Agency for International Development to accelerate clean air solutions in three pilot cities including Indore, India; Jakarta, Indonesia; and Nairobi, Kenya. Its core strategies are building awareness of the sources of air pollution through collecting and analyzing air pollution data, identifying solutions that address the root causes of pollution and building a strategic coalition to advance those solutions. CAC takes an integrated approach with the goal of reducing air pollution while achieving health and climate benefits, as well as mitigating gender disparities due to the disproportionate impacts of pollution on women and vulnerable populations. It also seeks to empower women as clean air champions.

In this highlight note, CAC wants to share what we know about air pollution in Indore, how it impacts health and the climate and what we can do about it. Our goal is to reduce emissions while empowering women as Clean Air Catalysts.

Sources of Air Pollution in Indore

Satellite observations indicate that air quality in Indore has been steadily declining over the last 10 years. Estimates using remote sensing and established relationships between air pollution and risk of adverse health outcomes indicate that across Indore in 2019, 620 children developed asthma due to high levels of air pollution. In the same year, 2,400 heart and lung disease deaths were due to air pollution (Southerland et al., 2022, Anenberg et al. 2022). While data from three manual monitors (from 2015) and one continuous monitor (from 2019) do exist to paint a broad-brush picture of air pollution levels in Indore, more robust and accurate data is needed to better understand air quality and pollution sources.

CAC is implementing a monitoring plan that will increase the spatial coverage, add speciated PM2.5 data to help separate contributions from sources and include the monitoring of additional air pollution species. This will include black carbon, which will be monitored both for source awareness and because it is a short-lived climate pollutant and one of the most important contributors to man-made global warming after carbon dioxide.

As part of this monitoring plan, CAC has signed an agreement to install three continuous ambient air quality monitoring stations at three different sites comprising of a supersite (government school) of mixed urban exposure, an upwind rural background site (government school) and a disadvantaged slum neighborhood site (government office) to measure PM2.5 and meteorological parameters, with additional measurements of carbon monoxide and black carbon at the supersite.

Existing data suggests that the largest source contributions in Indore are road transport, dust from construction, and resuspension of dust because of vehicle movement (Guttikunda & Jawahar, 2012, Guttikunda et al., 2019). Residential cooking fuel use and municipal waste burning are the second largest contributors to air pollution, followed by industry, diesel generators and brick manufacturing industries.

Few modeling studies have focused on Indore because of a lack of representative input data. The existing studies (Guttikunda & Jawahar, 2012, Guttikunda et al., 2019), however, do suggest that Indore has large spatial heterogeneity in annual average PM2.5 concentration over the city. CAC will test the emissions inventories developed by local scientists by evaluating Chemical Transport Model (CTM) performance before and after Indore-specific emissions have been added using CAC-developed, Indore-focused CTM modeling runs.

Using science and innovation to raise awareness of local sources of air pollution

CAC scientists are working to make pollution more visible and raise awareness of its sources–which will serve as the foundation for meaningful action. We are partnering with the Indore Municipal Corporation, Shri Govindram Seksaria Institute of Technology (SGSITS) in Indore, the Indian Institute of Technology (IIT) in Delhi and the Indian Institute of Science Education and Research (IISER) in Bhopal to conduct a source apportionment study, which uses samples of particulate matter to identify where those particles come from and the amount they contribute to ambient air pollution levels. The most feasible method currently available for characterizing the sizes and chemical constituents of particulate matter and its sub-fractions is particle sampling on filters. In order to meet various monitoring goals, ambient sampling systems are made up of a variety of monitoring gear, filter media, laboratory techniques and operating protocols (Aggarwal et al., 2010).

CAC is also working with partners to develop an emissions inventory. An emissions inventory is an accounting of the pollutants discharged into the atmosphere from all source categories in a certain geographical area and within a specific year, and it's the cornerstone for conducting source apportionment investigations and creating mitigation and control measures. Sources can be categorized as either general groups like the industrial and transportation sectors or specific subgroups like different industries, power plants and brick kilns. Air emissions inventories may be created for a single source or a very small area in addition to creating action plans to test the effectiveness of pilot projects or recently implemented control methods (TERI & EDF, 2022).

Air pollution impacts on gender and equity

In general, women and men from different socioeconomic groups are exposed to different levels of air pollution and occupational risks, have varying vulnerability to health impacts and suffer different consequences. Available evidence suggests that globally, women from low- and middle-income countries experience greater exposure to indoor air pollution from solid fuel use, increased harm from poor sanitation and waste burning and higher exposure to toxic chemicals in certain occupations such as the textile industry (OECD 2021). These disparities in pollution exposure are compounded by biological differences and social circumstances like poverty, gender inequality and discriminatory gendered cultural norms. Studies link air pollution to higher risk of cancer, cardiovascular disease, chronic obstructive pulmonary disease, stroke, diabetes, dementia and poorer reproductive outcomes with implications for future health of women. There are also intergenerational health implications, such as gestational diabetes, preeclampsia, low birth weight, still and premature births.

Global studies have also consistently shown that air pollution is most damaging for the health of children, the elderly and low-income communities (WHO 2022). People with preexisting disease face additional risks of worsening health outcomes when exposed to high levels of air pollution.

Air pollution can also have broader impacts on women through their household responsibilities. It may also be impacted by their options for modes of transportation, especially in low-income communities. A study conducted in Delhi found walking to be the transit mode leading to highest air pollution exposures, followed by rickshaw rides (Maji et al., 2021). Research suggests a link between air pollution and psychological factors affecting mental and physical health, cognitive performance and even violent behavior, of which women are the main victims (OECD 2021). More generally, women are especially exposed to risks in parts of cities which lack safe public spaces (under-lit and under-policed), are poorly connected to safe public transport and where crime rates can be high (UN Women).

Given gender-differentiated patterns of how people move and live in the city, identified sources of air pollution in Indore likely have differing impacts on men and women. However, with the exception of household indoor air pollution from cooking fuel, there is very limited Indore-specific information published around air pollution source contributions to exposure and gender and socioeconomic disparities (sex, income, and age). For example, researchers have found an association of higher PM2.5 concentration in districts with a higher percentage of Scheduled Castes, young children, and low-income households across Madhya Pradesh (Chakraborty and Basu, 2021). A few studies document disproportionate impacts from PM2.5 exposure on low-income roadside workers.

Based on both the existing data collected and with input from health experts, atmospheric scientists and civil society researchers, CAC has started characterizing the impact to communities from targeted sources of air pollution. Specifically, the program is looking at how children, women, the elderly, traffic policemen, electric rickshaw drivers, factory workers and people from low-income communities living near industrial slums are impacted in major traffic intersections across Indore and specific wards where industry and waste burning are more prevalent.

How air pollution impacts the climate

Air quality and climate change are strongly linked by the chemistry of pollutants, common emission sources and their impacts on human health. Firstly, ground-level ozone, its precursor methane and darker particulate matter like black and brown carbon are all short-lived climate pollutants (SLCPs) that accelerate warming and glacial melting (Institute for Governance and Sustainable Development, 2013); (USAID, 2022). Secondly, many major sources of air pollution such as vehicular fossil fuel exhaust emissions, waste burning, thermal power plants and industrial fuel combustion processes contribute to particulate matter emissions as well as the emission of short-lived climate pollutants such as black carbon and methane, and long-lived climate pollutants such as carbon dioxide. Similarly to air pollutants, short-lived and long-lived climate pollutants lead to the onset of pulmonary, respiratory and other chronic conditions and diseases impacting the heart and other critical organs (IPCC, 2018).

These interlinked impacts mean that actions taken to address air quality will also contribute to the reduction of the climate pollutants and protect public health (Zusman et al., 2021). The Madhya Pradesh State Climate Action Plan (2014) and the Climate Change and Environment Action Plan of Indore District (2022), the current guiding forces for climate action planning in the city, both recognize the reduction of air pollution as a co-benefit to mitigating greenhouse gas emissions.

CAC is committed to co-developing clean air solutions that reduce short-lived climate pollutant emissions. To this end, CAC is monitoring black carbon emissions to trace their sources within the city boundaries. In addition, to better understand the contribution of waste burning and transportation to CO_2 and CH_4, CAC will collect on-the-ground activity data as part of an integrated, bottom-up air and climate pollutant inventory. Insights from these data collection activities, combined with the estimation of emissions reductions from the project's proposed clean air solutions, will help CAC build a case for integrated clean air and climate action planning in Indore.

Building a coalition to drive solutions

CAC is building a coalition to drive solutions for clean air in Indore.

We have strong local scientific partners with expertise in atmospheric measurements, emissions inventories, modeling and source apportionment to work alongside a team of global partners. The CAC partnership is well-equipped to fill existing data gaps with local monitoring and modeling efforts and then to use the resulting information to identify priority sources and interventions for cleaner air, climate change mitigation and improved public health.

References

Aggarwal, A. L., Gargava, P., & Paathak, A. (2010). Conceptual Guidelines And Common Methodology For Air Quality Monitoring , Emission Inventory & Source Apportionment Studies For Indian Cities.

Anenberg, Susan C., et al. "Long-term trends in urban NO2 concentrations and associated paediatric asthma incidence: estimates from global datasets." The Lancet Planetary Health 6.1 (2022): e49-e58.

Catalogue of Indian Emission Inventory Reports, The Energy and Resources Institute and Environmental Defense Fund, January 2022

Chakraborty, J.; Basu, P. Air Quality and Environmental Injustice in India: Connecting Particulate Pollution to Social Disadvantages. Int. J. Environ. Res. Public Health 2021, 18, 304. ttps://doi.org/10.3390/ijerph18010304

Compendium of WHO and other UN guidance on health and environment, 2022 update. Geneva: World Health Organization; 2022 (WHO/HEP/ECH/EHD/22.01). License: CC BY-NC-SA 3.0 IGO.

Guttikunda, S. K., & Jawahar, P. (2012). Application of SIM-air modeling tools to assess air quality in Indian cities. Atmospheric Environment, 62, 551–561. https://doi.org/10.1016/j.atmosenv.2012.08.074.

Guttikunda, S. K., Nishadh, K. A., & Jawahar, P. (2019). Air pollution knowledge assessments (APnA) for 20 Indian cities. Urban Climate, 27, 124-141. https://doi:10.1016/j.uclim.2018.11.005

IGSD (2013) Primer on Short-Lived Climate Pollutants, Institute for Governance and Sustainable Development, February 2013. http://igsd.org/documents/PrimeronShortLivedClimatePollutantsFeb192013.pdf

IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

[Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24. https://doi.org/10.1017/9781009157940.001

Maji, Kamal & Namdeo, Anil & Hoban, Dan & Bell, Margaret & Goodman, Paul & SM, Shiva Nagendra & Barnes, Jo & De Vito, Laura & Hayes, Enda & Longhurst, J. & Kumar, Rakesh & Sharma, Niraj & Kuppili, Sudheer Kumar & Alshetty, Dheeraj. (2021). Analysis of various transport modes to evaluate personal exposure to PM2.5 pollution in Delhi. Atmospheric Pollution Research. 12. 417-431. 10.1016/j.apr.2020.12.003.

OECD (2021), Gender and the Environment: Building Evidence and Policies to Achieve the SDGs, OECD Publishing, Paris, https://doi.org/10.1787/3d32ca39-en.

Pomeroy-Stevens, Amanda, Bachani, Damodar, Sreedhara, Meera, Boos, John, Amarchand, Ritvik & Krishnan, Anand. (2020) Exploring urban health inequities: the example of non-communicable disease prevention in Indore, India, Cities & Health, DOI: 10.1080/23748834.2020.1848327

Ross, K., T. Damassa, E. Northrop, A. Light, D. Waskow, T. Fransen, and A. Tankou. 2018. "Strengthening Nationally Determined Contributions to Catalyze Actions That Reduce Short-Lived Climate Pollutants. Working Paper. Washington, DC: World Resources Institute. Available online at www.wri.org/publications/reducing-SLCPs

Southerland, Veronica A., et al. "Global urban temporal trends in fine particulate matter (PM2· 5) and attributable health burdens: estimates from global datasets." The Lancet Planetary Health 6.2 (2022): e139-e146.

State Knowledge Management Center on Climate Change (2014). Madhya Pradesh State Action Plan on Climate Change. http://www.climatechange.mp.gov.in/sites/default/files/ongoing-projects/Madhya%20Pradesh%20State%20Action%20Plan%20on%20Climate%20Change.pdf

USAID, 2022. Short-Lived Climate Pollutants and USAID's Climate Strategy: Achieving Fast Mitigation. Available online at https://urban-links.org/wp-content/uploads/SLCP-Technical-Brief_6-29-2022_FINAL-508_.pdf

Vasudha Foundation (2022). Climate Change and Environment Action Plan of Indore District

WHO, 2022. WHO Air quality database, 2022. Accessed on 03-08-2022 from https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database#cms

Zusman, E., Unger, C., Borgford-Parnell, N., & Mar, K. A. (2021). One Atmosphere: Integrating Air Pollution and Climate Policy and Governance. Atmosphere, 12(12), 1570. https://doi.org/10.3390/atmos12121570