CLEAN AIR CATALYST

Sources of Air Pollution: Indore

Lead Authors:

Ajay Nagpure, World Resources Institute

Nivedita Barman, Environmental Defense Fund

CONTRIBUTORS

World Resources Institute: Beatriz Cardenas, Elizabeth Moses, Ken Wakabayashi, Saifi Izhar, Sanjar Ali, Ritesh Kumar, Vandana Tyagi

Environmental Defense Fund: Tammy Thompson, Kaushik Hazarika, Ramon Alvarez

Columbia University: Jacqueline M Klopp

MAPAQ (Monitoring, Analysis, and Prediction of Air Quality): Rajesh Kumar

REVIEWERS

Vital Strategies: Sumi Mehta

Columbia University: Faye McNeill, Steve Chillrud, Darby Jack, Jacqueline M Klopp

Clean Air Catalyst

A cooperative by:

EXECUTIVE SUMMARY

Nine out of 10 people globally breathe air with levels of pollutants that exceed World Health Organization (WHO) air pollution guidelines, according to WHO data (WHO updated those guidelines in September 2021, and the statistics may change with those updates). 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 top 15 Cities with the worst fine particulate matter (PM2.5) pollution.

Indore, with a population of more than 3.4 million, 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). The air pollution data available over the past five years from two manual sites in Indore suggest that PM2.5 concentrations exceed WHO annual average standards of 10 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 during these months.

Air Quality Monitoring

Data from three manual monitors (from 2015) and one continuous monitor (from 2019) do exist to paint a broad-brush picture of the air pollution situation in Indore; however, more data are needed. Clean Air Catalyst is building a monitoring plan that will increase the spatial coverage, add speciated PM2.5 data to help separate contributions from sources using sources' unique ratios of PM2.5 species, and include the monitoring of additional air pollution species, including black carbon, which will be monitored both for source awareness and because it is a short-lived climate pollutant.

Emissions Inventories

Local emission factors are not available for most of the emission sectors in Indore, or elsewhere in India, except for limited availability from the transport sector. The inventories regularly used to model air pollution in India are typically developed for global-scale modeling studies and use very generalized emissions factors, often from the Compilation of Air Pollutant Emissions Factors database (AP-42) of the U.S. Environmental Protection Agency (U.S. EPA) and regional or national activity data. The emissions inventories suggest that the largest source contributions in Indore are road transport, dust from construction, and resuspension because of vehicle movement. 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. Clean Air Catalyst scientists are using local air pollution source activity data to improve emissions inventories for Indore and thus improve the understanding of air pollution activity hotspots and improve model performance of chemical transport modeling (CTM) over Indore. The new emissions inventory will help guide the development of clean air strategies.

Air Pollution Modeling

Few modeling studies have focused on Indore because of a lack of representative input data. The existing studies, however, do suggest that Indore has large spatial heterogeneity in annual average $PM_{2.5}$ concentration over the city. Clean Air Catalyst will test the emissions inventories developed by local scientists by evaluating CTM performance before and after Indore specific emissions have been added using CAC-developed, Indore-focused CTM modeling runs.

As a first look, the numerical transport model Weather Research and Forecasting with Chemistry (WRF-Chem), with externally developed global emissions inventories used as input, is used to track emissions of carbon monoxide (CO) and primary $PM_{2.5}$ from 22 geopolitical regions in India. Model domain boundary conditions and the emissions source sectors of anthropogenic fires and biomass burning are tracked separately. Initial findings for a January model run suggest that emissions from Indore itself make up the largest single contributor to air pollution in Indore; however, 70–80% of air pollution comes from sources outside Indore.

Equity, Gender, and Climate

Based on the preliminary infrastructure provision data obtained, CAC has started characterizing different communities in the city and assessing their contributions and exposure to air pollution sources. A few studies document disproportionate impacts from $PM_{2.5}$ exposure on low-income roadside workers; transport and, more broadly, roadside emissions could be a priority focus, especially in areas where traffic is combined with industrial or commercial activities such as restaurants or small manufacturing, which engage vulnerable populations, including women, as labor. Given gender-differentiated patterns of how people move and live in the city, identified sources of air pollution in Indore likely have differential impacts. However, much more work must be done to explore vulnerabilities disaggregated by sex, age, and other socioeconomic categories.

Conclusions and Next Steps

The CAC consortium includes strong local scientific partners with expertise in atmospheric measurements, emissions inventories, modeling, and source apportionment to work alongside a team of global partners. Data gaps exist, but the skill set of the CAC consortium is well able to fill those 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 lower exposure.