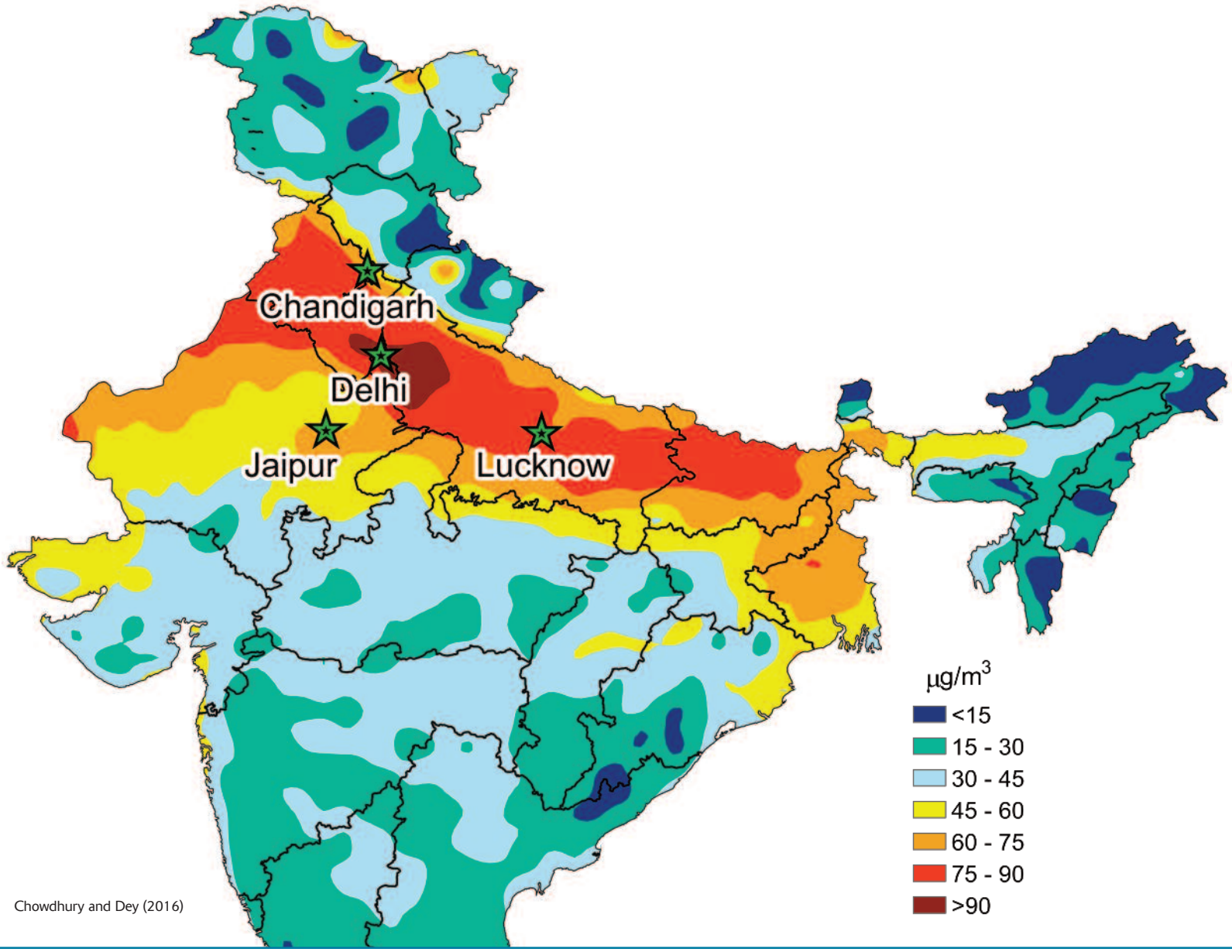

Chowdhury and Dey (2016)

Combating Air Pollution in North India

The Path Forward

by Prakash Doraiswamy, R.K.M. Jayanty, S.T. Rao, Manju Mohan, Sagnik Dey, Dilip Ganguly, Saroj K. Mishra, Ramesh Jain, Mark Azua, and Ayesha Gideon

An overview of the stakeholder recommendations to tackle the significant fine particulate matter pollution burden in Delhi, India, that has gained global attention in the past few years.

Air pollution in North India is a serious problem that has recently gained global attention.[1-3] Based on data published by the World Health Organization,[4] Delhi and 11 other North Indian cities rank among the top 25 cities in the world with the highest fine particulate matter (particulate matter with aerodynamic diameter of 2.5 µm or less, PM2.5) concentration levels in the world (see Figure 1). The annual average PM2.5 concentration in Delhi is typically more than 10 times the U.S. National Ambient Air Quality Standard of 12 µg/m^3 (see Figure 2). Such poor air quality has significant economic and health impacts (e.g., heart attack, asthma, lung cancer, mortality).[5-6] Pope et al (2015)[7] discussed the non-linear nature of the concentration-response function relevant to highly polluted environments like India and China.

Delhi, the capital of India, is located in the northern region of India. Delhi and its immediate adjoining cities, referred to as the Delhi National Capital Region (NCR), account for a population of 21.7 million (2011 census)[8] and is the 10th largest megacity in the world. It sits in the Indo-Gangetic Plain, a densely populated region that runs in parallel to the south of the Himalayan Mountains (see Figure 3).

An examination of the World Health Organization data[4] indicates potentially significant local pollution, but also a high background concentration prevailing regionally over most of North India. The sources of air pollution vary between locations. Rural regions may be impacted more by open burning (e.g., burning of paddy straw in Punjab and Haryana), while urban regions may be impacted more by vehicles and industries. In addition, meteorology plays an important role in the transport of emissions downwind, as well as in trapping pollution during winter months. Thus, the air pollution problem in North India requires a coordinated effort with participation from both regional and local stakeholders. To this end, in 2016 the U.S. Embassy's North India Office in New Delhi sponsored a series of workshops on air quality to bring together the Indian stakeholders. This article summarizes the workshop proceedings and the recommendations that were generated at the workshops to combat the air pollution problem in Delhi and North India.

India–U.S. Air Pollution Workshops

A team led by RTI International, USA, in collaboration with the Indian Institute of Technology Delhi, organized a series of workshops at four locations (Figure 3) in North India from May 17–May 26, 2016: Delhi (May 17–18), Chandigarh (May 20–21), Jaipur (May 23–24), and Lucknow (May 25–26). The objectives of the workshops were to provide a forum for all Indian stakeholders to meet and exchange ideas, and to develop a strategy for improving the air quality. The workshops brought together Indian stakeholders and U.S. scientists and fostered a dialogue to exchange ideas and share best practices (see Figures 4 and 5). The Indian stakeholders included Indian central and state/local government officials representing the pollution control boards, industry representatives, small businesses and entrepreneurs, scientists, university researchers and students, other non-governmental organizations, and citizen groups.

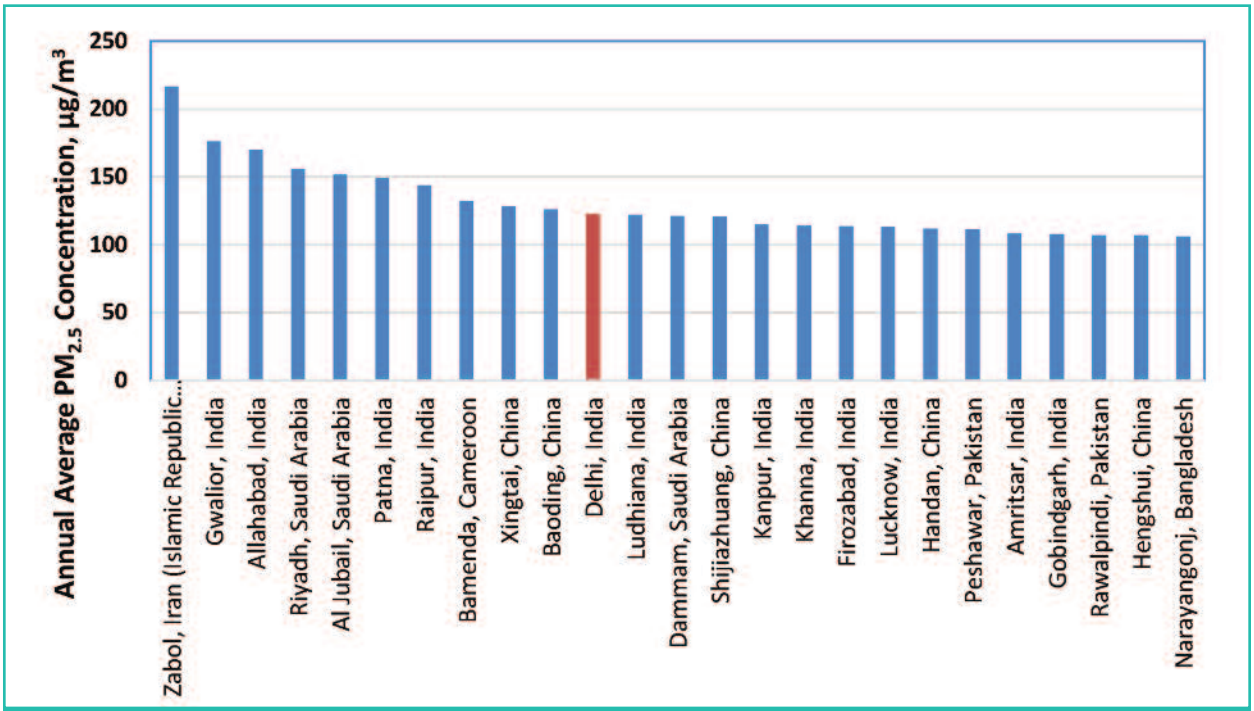

Figure 1. Delhi and 11 other North Indian cities are ranked among the top 25 cities with the worst air quality in the world.

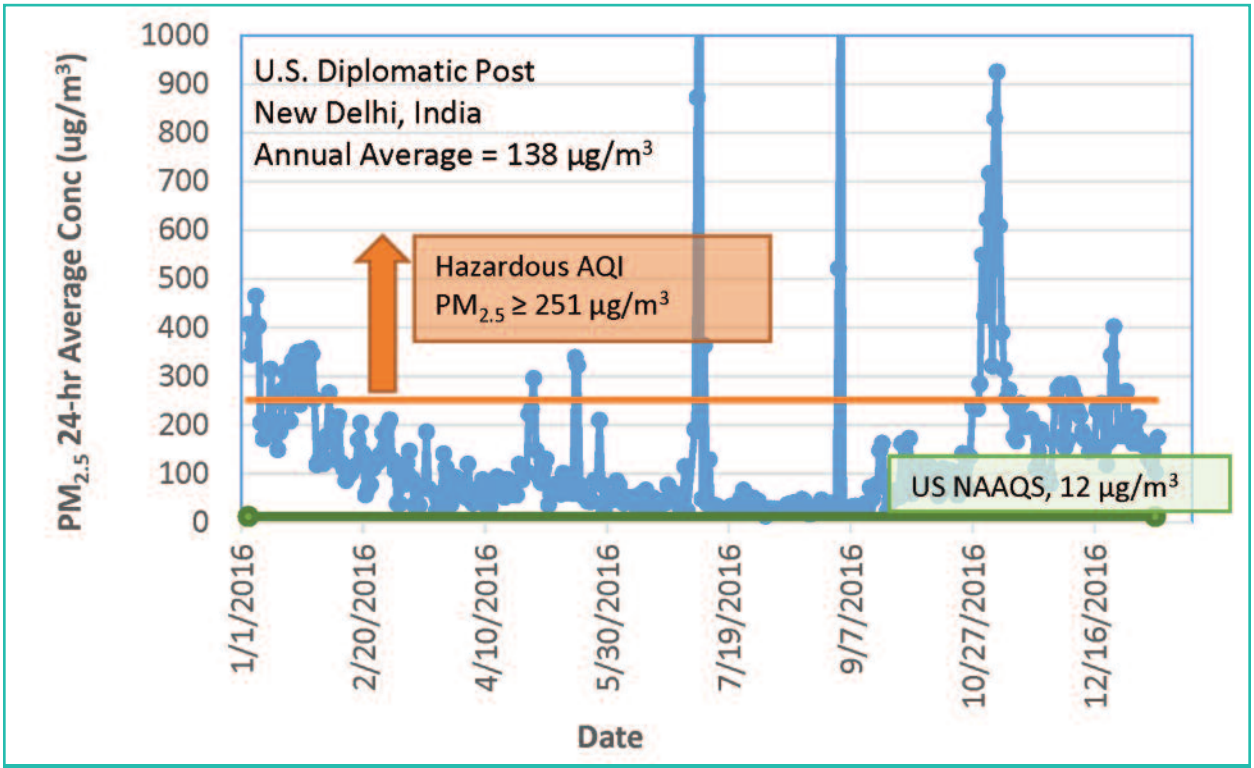

Figure 2. Daily average PM2.5 concentrations at a site in Delhi (*data source:* openaq.org).

Each workshop featured presentations by both Indian and U.S. experts on the health effects of air pollution, insights from measurements, industry efforts, and air pollution policy, followed by breakout sessions and panel discussions. Around 40–60 participants representing various stakeholder groups attended the workshops. The participants were encouraged to participate in a breakout group in their area of interest: air quality and health; air quality measurements and accountability (including emission inventories and modeling); and regulations, industry efforts, and industry–government relationship. Each breakout group was provided with a set of focus questions to deliberate and develop a list of recommendations. These recommendations were further refined as part of a concluding panel discussion at each workshop location. The workshops fostered healthy discussion among all the participants and built group consensus on air quality. The workshops focused on laying out the problems, identifying gaps in data, and developing short and long-term goals and recommendations toward addressing these gaps.

Ongoing Efforts and Key Gaps

As shown in Figure 2, PM2.5 concentrations over the past year averaged to 138 µg/m^3 on an annual basis. Approximately 84 percent of the days experienced PM2.5 levels that are unhealthy for sensitive populations (PM2.5 ≥ 35.5 µg/m^3, Air Quality Index [AQI] scale > 100); 67 percent of the days experienced PM2.5 levels that are in the unhealthy range for all population (PM2.5 ≥ 56 µg/m^3, AQI > 150); and 13.5 percent of the days experienced PM2.5 levels that are in the hazardous conditions (PM2.5 ≥ 251 µg/m^3, AQI > 300), as defined by the AQI scale in the United States.[9] Daily average concentrations in November 2016 exceeded 900 µg/m^3 coinciding with the Diwali festival in India (during which fire crackers are used, worsening the problem), forcing the Delhi government to temporarily close schools.[10] Such short-term measures are now being implemented by the government. In December 2016, the Central Pollution Control Board (CPCB) developed the Graded Response Action Plan (in response to the Supreme Court mandate) that has enumerated a number of measures, including emergency measures in response to pollution levels. While such steps are being taken, the workshop discussions revealed gaps and areas for improvement both in the short and long term.

Discussions revealed that while the Global Burden of Disease Study estimates[11] have led to several initiatives, epidemiological studies have thus far not driven the air pollution control policy in India. Public awareness and education also seem to be heavily focused only in urban areas and need to be expanded to rural regions. One of the major gaps identified is a lack of high-quality air quality and health effects data that are accessible and archived. The CPCB maintains a network of approximately 342 stations that monitors sulfur dioxide, nitrogen dioxide, and particulate matter with aerodynamic diameter of 10 µm or less (PM10), and plans to expand it to include PM2.5. There is currently no routine PM2.5 speciation program in place in India. The CPCB has also been mandated to expand air quality monitoring by 2017 to all cities with > 1 million population.

Figure 3. Map of North India and surrounding regions showing topography and workshop locations (World Imagery - Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community).

New regulations implemented in 2016 require 17 industrial sectors to install continuous emission monitoring systems (CEMS) with features to transmit data in real-time to the CPCB, and to automatically alert regulators in the event of an emission exceedance. Such measures are being initiated by the CPCB, although the lack of sufficient resources appears to limit their ability to fully address the problem, including full implementation and follow-up. Limited emissions inventory data are available from the System of Air Quality Weather Forecasting and Research (SAFAR) program at the Indian Institute of Tropical Meteorology, but there is no comprehensive national level emission inventory system currently in place. Multiple research efforts appear to be underway to develop high-resolution emission inventories for specific source categories.[12] Likewise, multiple measurement campaigns by university research groups appear to be ongoing. Given the paucity of measurement data in India, gathering disparate sources of data in a central data repository would enable leveraging existing studies.

Recommendations for a Path Forward

The detailed recommendations generated through the stakeholder discussions are summarized in a report.[13] Key recommendations are highlighted here. It was recommended that the Ministry of Health and the Ministry of Environment should coordinate and formulate policies considering the effects of air pollution on human health, a direction in which the government is now shifting. On a long-term basis, standards should be defined based on epidemiological studies specifically from India. It was also recommended that the CPCB should consider adding a PM2.5 speciation network to enable tracking air pollution and its composition over time and help link the pollutants to sources. Lack of good data quality undermines the value of the data and the trust of the public. Therefore, measures should be implemented to improve and maintain a rigorous quality assurance program for all air monitoring networks.

Improving data availability, accessibility, and reliability through online data portals would enable better understanding of the problem, build public awareness, ensure independent quality review, and help devise meaningful and cost-effective policies. The Indian government should consider expanding its initiative on "Digital India" to include an online data portal for air quality and health data. Developing detailed emission inventories is essential to understand sources and emissions and to devise

Figure 4. Deliberation and exchange of ideas during a breakout session on regulations and industry–government relationship at the Delhi workshop.

Figure 5. Group photo at the conclusion of the Delhi workshop.

control strategies. Allocating more resources to the CPCB and State Pollution Control Boards will empower these agencies to expand their program and address the imminent air pollution problem over the near and long term. A growing economy with rapid urbanization necessitates long-term planning via interagency collaboration among the concerned ministries. Finally, the public also has a role in controlling air pollution. Increased public awareness and education, both about the impacts of air pollution on health, as well as about measures that one could take to lower exposure, would empower citizens with the knowledge to do their part in improving the air quality and protecting their health.

Conclusions

The air pollution problem in North India arises from a myriad of large and small distributed sources that makes mitigation challenging. Given the magnitude of the problem, any step taken toward reducing emissions is a step in the right direction. The recommendations generated from these workshops form the foundation for generating more data and addressing issues in the short term, which together will help develop long-term strategies to achieve healthy air quality throughout India. Experience from the United States and other developed nations have shown that it is feasible to continue sustained economic growth while protecting human health and the environment through meaningful cost-effective control strategies. **em**

Acknowledgment: The authors thank the U.S. Embassy's North India Office in New Delhi for funding this work.

Prakash Doraiswamy and **R.K.M. Jayanty** are with RTI International. **S.T. Rao** is an adjunct professor at North Carolina State University. **Manju Mohan, Sagnik Dey**, **Dilip Ganguly**, and **Saroj K. Mishra** are all with the Indian Institute of Technology, Delhi, India. **Ramesh Jain** was previously with the U.S. Embassy Public Affairs Division. **Mark Azua** and **Ayesha Gideon** are with the U.S. Embassy Public Affairs Division in Delhi, India. RTI led the effort with Prof. S. T. Rao serving as an advisor, and conceptualized the workshop series. Prof. Mohan and her team led the local organization of the workshops in India. The U.S. Embassy at Delhi funded the effort and helped shape these workshops. E-mail: **pdoraiswamy@rti.org**.

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