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A synergistic view of urbanization impact on degradation of air quality in major Indian cities

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India has been undergoing rapid urbanization and urban expansion posing a serious challenge to sustainable growth for the cities. Majority of these cities either do not have any ground-based monitoring of fine particulate matter (PM2.5) or they have only one or a handful of sites not representative of the heterogeneity in PM2.5 exposure. Even the cities that have multiple sites, measurements started after 2009. Therefore, how ambient PM2.5 has been changing and how much of it can be attributed to urbanization is not known.

Here we analyze AOD (aerosol optical depth) data at a resolution of 1 km $\times$ 1 km retrieved by MODIS (Moderate Resolution Imaging Spectroradiometer) using the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm and generate PM2.5 using scaling factors derived from chemical transport models constrained by observations for 58 cities for 2001 and 2015. These cities have been identified under the 'smart city mission' launched by the Govt. of India. We spatially identify each1-km grid as rural/urban/no-settlement based on global human settlement data for the same period. The changes in ambient PM2.5 in each city and its suburbs are quantified relative to the change of PM2.5 in the no-settlement class that is considered as the background. Changes in PM2.5 in each grid are categorized to three different groups – grids that remained urban throughout, grids that remained rural and grids that became urban (either from rural or no-settlement).

We present summary statistics of the pattern of changes in ambient PM2.5 by broadly classifying these 58 cities into large (>3 million population), medium (1-3 million population) and small (<1 million population) cities. We show that ambient PM2.5 has increased by 9% (5th-95th percentile range 3-19%), 4.9% (-0.3-11%) and 6.5% (1.5-19%) respectively in the grids that became urban in this period, remained rural and remained urban in this period due to increase in emission from urban activities above the background level (that takes care of regional transport). The urban-rural divide in air quality degradation is more pronounced in the medium and large cities than in the smaller cities. Our results clearly demonstrate that urban development in India should have an air quality management plan. Since the population in the cities has been increasing, the observed increase in PM2.5 is expected to have a larger impact on health burden. We urge developing city-specific action plan to reduce air pollution burden especially when the urban migration is projected to increase manifold within next few decades in order to achieve United Nations' 11th sustainable development goal for 2030. Our results further demonstrate the utility of new generation space-based aerosol products for air quality management at urban scale.