Foreword

Environmental impact of the COVID-related lockdown and unlock over the Indian region

Even though it is well accepted that anthropogenic emissions significantly perturb our environment through short- and long-lived climate forcing agents, the role of short-lived climate forcers (SLCF) such as aerosols (composite and carbonaceous) and some of the trace gases (such as CO and oxides of nitrogen) has been drawing increased attention in the recent years due to a variety of reasons (IPCC AR5)[1]. Quantifying the climate impact of SLCFs is challenging due to their highly heterogeneous nature (both in space and time), the short atmospheric lifetime (5–10 days in lower atmosphere) and heterogeneous chemical composition. Though, both natural and anthropogenic emissions and the subsequent chemical reactions in the atmosphere contribute to the abundance of these in the atmosphere, the main contributors are believed to be anthropogenic emissions from industrial activities, transport (air, surface and marine) sectors and from power generation (using fossil fuels) and widespread use of biomass and fossil fuels for domestic use. It is very difficult and challenging to delineate them accurately and consequently quite a bit of 'environmental bickering' takes place between different lobbies in India, as to who is responsible for severe degradation of environment and air quality. While some point fingers to biomass use (wood, dung and other such material) by the economically weaker sections of the society, some blame the seasonal stubble burning and some others point fingers towards the extensive fossil fuel-based emissions from the automobile, industrial, aircraft, shipping and rail traffic sectors. While each one has its own share, it often becomes difficult to delineate one from the other as the source processes are ever prevailing.

To contain the spread of Coronavirus Disease 19 (COVID-19) pandemic in India, the Government of India imposed a complete lockdown over the entire country from 24 March to 3 May 2020, before partially relaxing it from 4 May. This lockdown, though did not impact domestic activities in a major way, has resulted in almost total shut down of several big industries, large business and commercial establishments, educational institutions, traffic (air traffic, rail traffic, marine traffic and a near-total restriction of road traffic) and a large reduction in coal power generation for nearly six weeks. This lockdown, for a duration significantly longer than the atmospheric life-time of several short-lived forcing agents, provided a unique and rare opportunity for examining and assessing the responses of air quality and environmental conditions to the regional cessation of fossil-fuel based emissions, based on primary data from analytical measurements as well as from satellite retrievals. The subsequent relaxations leading to phased unlocks also showed how the conditions changed as the activities slowly returned to normal. Though there have been several media reports of conspicuous improvement in air quality and visibility, a consolidated and quantitative assessment, based on scientific measurements alone would provide important inputs to policy makers and planners.

This special section contains 11 scientific contributions on the above aspect from various research and academic institutions across the country, based on primary measurement data. Some of the results that have emerged include:

- A large reduction, by a factor of >50% in the ambient concentration of black carbon (BC) from fossil fuel emissions (mainly from the transport sector) in major urban conglomerations across the country. At the peak of the decrease, the concentration of aerosols in urban areas were comparable to those in rural areas.
- In line with the above, there is a simultaneous large reduction in the concentrations of oxides of nitrogen, again, emitted basically from automobiles. The reduction was noticed not only in the ambience, but in entire troposphere. Satellite data showed 50–70% decrease in the tropospheric column NO_2 over several megacities during the strict lockdown phase, vindicating the effect of cessation of vehicular emissions. Though some of the above are logically to be expected, the quantification of the contribution of transport sector to the urban pollution is a very important result, both from the perspectives of environment and health. These would be important inputs to the agencies concerned with forming policies for improving air quality in the country.
- Delineation of the carbonaceous aerosols in terms of their source strengths (from fossil fuel and biofuel) reveals that BC from bio-fuel emissions contributes only about 10–15% of total BC concentration in the ambient air, while BC from fossil fuels constitutes about 80%.
- In the rural and remote areas, there were no conspicuous impacts of the lockdown, vindicating that the emissions from domestic sectors did not show any significant impact due to lockdown and also, they contributed only a very small fraction of the total concentration of aerosols and trace gases.
- Interestingly, in contrast to the scenario near the surface and within the atmospheric boundary layer, the columnar AOD (a measure of the columnar aerosol loading) did not show significant decrease owing to other large-scale processes. Satellite observations revealed increased aerosol loading in some of the subregions, which was caused by advected aerosols in the

free troposphere, aided by changes in the synoptic meteorology.

- Similar changes are seen in column concentration of trace gases such as NO_x and ozone (due to chemistry involving oxides of nitrogen). Model simulations lead to results in general conformity to the data.
- The results also show how the environment gets recharged by these species linked to anthropogenic emissions as the lockdown conditions were gradually relaxed, permitting more and more vehicular movements in a phased manner.

This is, perhaps, first-time a delineation of the contribution of emissions from the transport sector to the environmental degradation has been done in India. The details, the processes involved and their implications are discussed in the articles that appear in this special section. While these are preliminary results, more detailed analyses of the data from different institutions and more detailed scientific results are expected in the coming years. We hope that these results would provide important inputs to planners and policy makers.

1. Cubasch, U., Wuebbles, D., Chen, D., Facchini, M. C., Frame, D., Mahowald, N. and Winther, J.-G., IPCC AR5: Introduction. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (eds Stocker, T. F. *et al.*), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013.

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