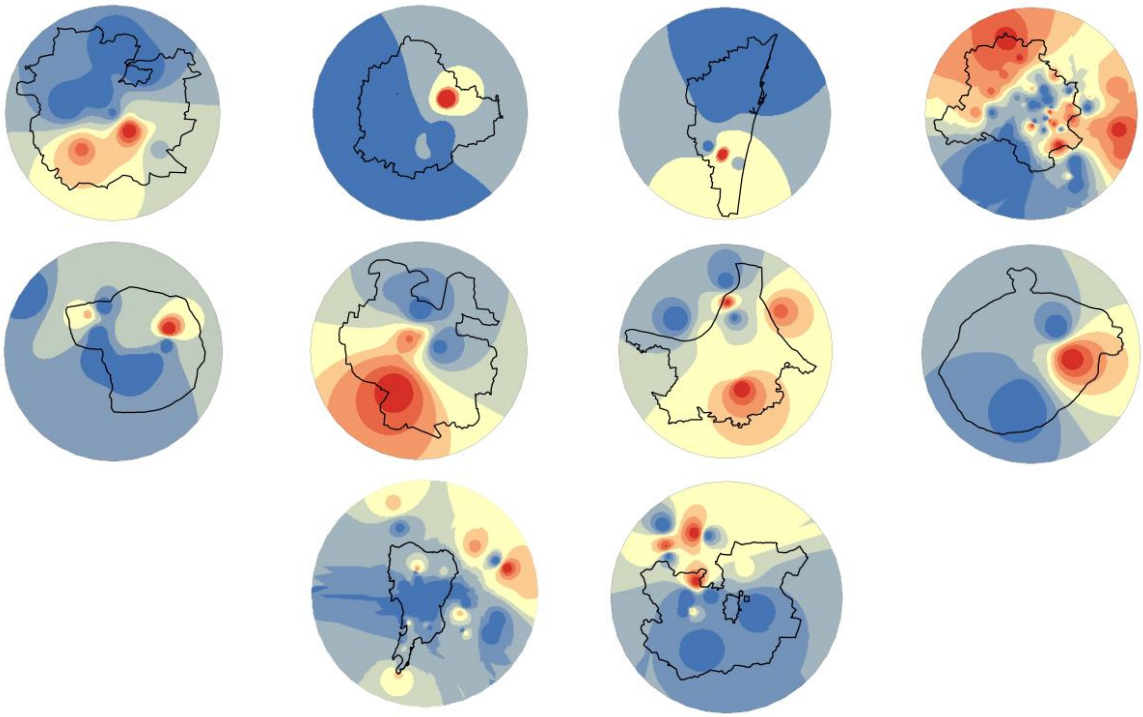
Air Quality Tracker

Ground-level Ozone



An invisible threat

Summary report of ground-level ozone pollution analysis of 10 major metropolitan areas of India

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Summary report of ground-level ozone pollution analysis of 10 major metropolitan areas of India

Overview

Centre for Science and Environment (CSE) has alerted from time to time about the growing problem of ground-level ozone in Indian metropolitan areas. While policy and public attention is nearly fully drawn towards very high level of particulate pollution, the challenge of this highly toxic gas has not attracted adequate policy attention for mitigation and prevention. Inadequate monitoring, limited data and inappropriate methods of trend analysis have weakened the understanding of this growing public health hazard. This requires early action.

The summer of 2024 has witnessed widespread ground-level ozone exceedance making the air more toxic across 10 major metropolitan areas of India. This time the geographical spread of the problem is much wider than the lockdown summer of 2020 in most metropolitan areas. The phase of the toxic built up has lasted longer in locations affected by the problem. Even the smaller metropolitan areas have witnessed rapid increase. In metropolitan areas in the south and western coastal belt the problem is not limited only to summer months.

This stark evidence has emerged from the recent analysis by CSE that has been alerting time and again about the growing problem of ground-level ozone in Indian metropolitan areas.

As the National Clean Air programme (NCAP) is gearing up for the second phase, its reform agenda has to address the multi-pollutant crisis and the combined threat from PM2.5, ozone, nitrogen oxides and other gases. This highly reactive gas has serious health consequences. Global experience shows that there is usually a trade-off. As particulate pollution is reduced the problem of nitrogen oxode (Nox) and ground-level ozone increase. This requires significant tightening of the regulatory benchmark for ozone to address the toxic emisisons from industry, vehicles, households and open burning.

Moreover, ozone not only builds up in metropolitan areas but also drifts long distances to form a regional pollutant that makes both local and regional action necessary.

Currently, inadequate monitoring, limited data and inappropriate methods of trend analysis have weakened the understanding of this growing public health hazard. Complex chemistry of ground-level ozone makes it a difficult pollutant to track and mitigate. Due to the very toxic nature of ground-level ozone, the national ambient air quality standard for ozone has been set for only short-term exposures (one-hour and eight-hour averages), and compliance is measured by the number of days that exceed the standards. This requires early action.

Why ozone needs special attention? Ground-level ozone is not directly emitted from any source. It is produced from complex interaction between nitrogen oxides (NOx) and volatile organic compounds (VOCs) that are emitted from vehicles, power plants, factories, and other combustion sources and undergo cyclic reactions in the presence of sunlight to generate ground-level ozone. VOCs can also be emitted from natural sources, such as plants.

Those with respiratory conditions, asthma, chronic obstructive pulmonary disease, and particularly children with premature lungs and older adults are at serious risk. This can inflame

and damage airways, make lungs susceptible to infection, aggravate asthma, emphysema, and chronic bronchitis and increase the frequency of asthma attacks leading to increased hospitalisation.

The 2020 State of Global Air report states that age-standardized rates of death attributable to ground-level ozone is among the highest in India and the seasonal 8-hour daily maximum concentrations have recorded one of the highest increases in India between 2010 and 2017 – about 17 per cent. This requires deeper understanding of what is going on to inform mitigation.

The investigation: This assessment has traced trends during summer (1 April-18 July). The data covered is from 2020 to 2024. The analysis is based on publicly available granular real time data (15-minute averages) from the CPCB's official online portal Central Control Room for Air Quality Management. The data has been captured from official stations under the Continuous Ambient Air Quality Monitoring System (CAAQMS) spread across 10 metropolitan regions. Delhi-National Capital Region (58 stations), Mumbai Metropolitan Region (48 stations), Kolkata Metropolitan Area (10 stations), Greater Hyderabad (14 stations), Bengaluru Metropolitan Area (14 stations), Chennai Metropolitan Area (9 stations), Pune Metropolitan Region (15 stations), Greater Ahmedabad (10 stations), Greater Lucknow (7 stations) and Greater Jaipur (6 stations).

Given the volatile and highly localized nature of ground-level ozone pollution build-up and its variability across space, and consistent with the global good practice, this analysis has considered station level trends in terms of number of days exceeding the 8-hour standard over time. As ozone formation depends on complex atmospheric chemistry and on photochemical reaction its level varies across time and space horizon. Meteorological parameters such as sunny and warm weather, stagnant wind patterns etc have bearing on its formation. This analysis tracks exceedances at each station in core NCR. Breach of the standard by even one station is considered exceedance by the core NCR. Days with multiple stations exceeding the standard indicates the severity of the spatial spread and number of people exposed. Given that the data is capped at 200 $\mu g/m^3$ by CPCB, it is not possible to determine how high the concentration really goes.

The study has considered global good practice and taken on board the USEPA approach of computing eight-hour averages for a day and then checking for the maximum value among them to capture the daily ozone pollution level. USEPA assesses city-wide or regional AQI based on the highest value recorded among all stations of the city or the region. Thus, trends have been calculated in terms of number of days when the daily level has exceeded the 8-hr standard (referred as exceedance days hereafter).

While analysing the data it has also been noted that the ozone data available on CPCB portal never exceeds 200 $\mu g/m^3$, while data for the corresponding time on Delhi Pollution Control Committee may show higher levels. Therefore, due to this capping of data it is not possible to understand the nature of peaking in the city. This needs to be addressed as there are two sets of standard for ozone – 8-hourly standard of 100 $\mu g/m^3$ and one hourly standard at 180 $\mu g/m^3$. Capping makes assessment of one-hourly standard challenging.

Key highlights

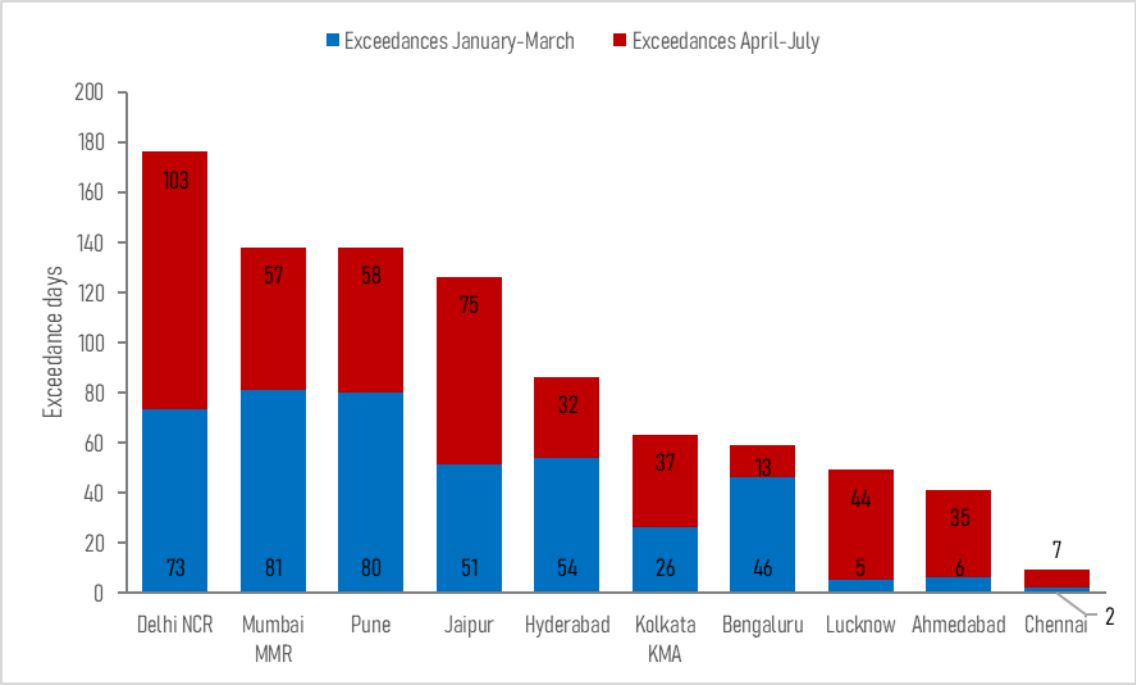
Monitoring of ozone and method of its trend analysis need to improve to inform policy: Compliance method as set by the Central Pollution Control Board (CPCB) requires that the ozone standards are met for 98 per cent of the time of the year. It may exceed the limits on two per cent of the days in a year, but not on two consecutive days of monitoring. In other words, there should not be more than eight days in a year when the ozone standard is breeched, and none of those allowed exceedances can be on two consecutive days.

The standard practice of CPCB to average out the data of all stations in the city to determine daily AQI does not work for ground-level ozone as it is a short-lived and hyper-localised pollutant. A citywide average concentration level over an extended time frame does not indicate the severity of the problem and health implication from local build up and exposure for people living in hotspots.

Ground-level ozone exceedance is reported in all ten metropolitan areas with Delhi being the most affected: This year so far Delhi-NCR has recorded 176 days of ground-level ozone exceedances during the study period - between April and July. This is the worst among ten metropolitan areas analysed in this study. Mumbai-MMR and Pune are tied for the second spot with 138 days of exceedance each (See *Graph 1: Ground-level ozone exceedances in ten major metropolitan areas of India*). Jaipur recorded exceedance on 126 days and Hyderabad on 86 days. Kolkata-KMA had 63 exceedance days while Bengaluru had 59 exceedance days. Lucknow and Ahmedabad recoded 49 days and 41 days of exceedance. Least number of exceedance were recorded in Chennai with just 9 days.

Ground-level ozone exceedance is more frequent during summer for Delhi-NCR, Jaipur, Kolkata-KMA, Lucknow, Ahmedabad and Chennai. In Mumbai-MMR, Pune, Hyderabad, and Bengalure more exceedances were reported during January-March than during summer (April-July).

Graph 1: Ground-level ozone exceedances in ten major metropolitan areas of India

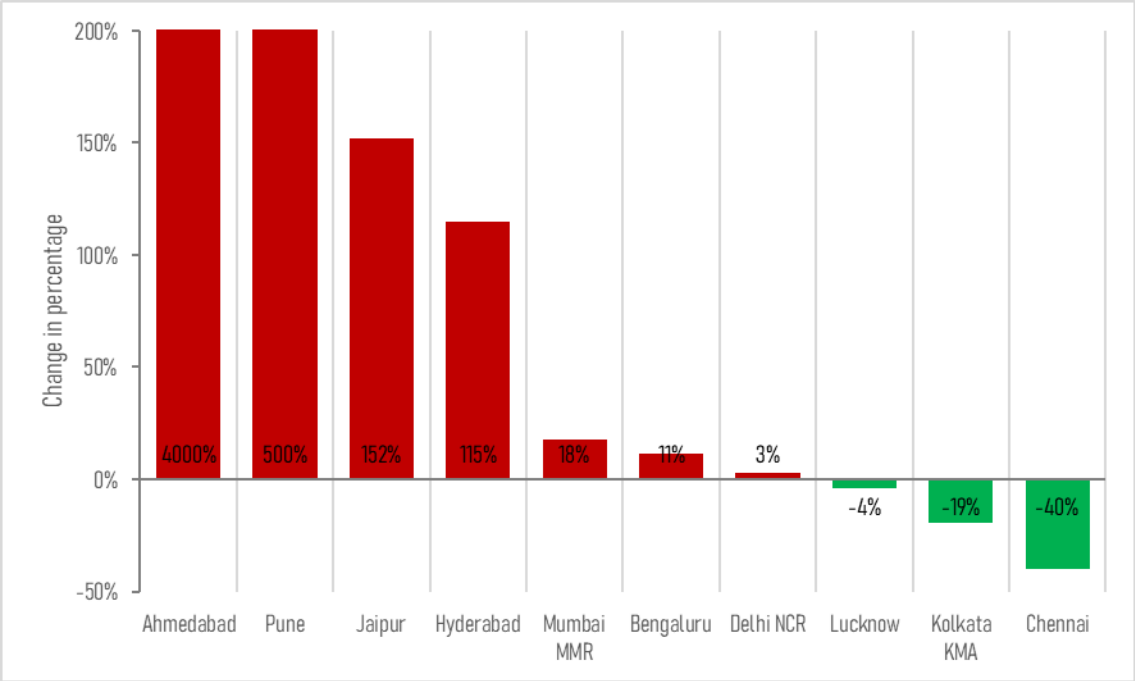


Note: Based on exceedances recorded at each monitoring stations of every city. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m^3. Data up till 18 July 2024.
Source: CSE analysis of CPCB realtime data.

Stunning increase in ground-level ozone exceedance is reported in smaller metropolitan areas: Comparing the number of exceedances this year so far with the same period from last yeas shows that increase in 7 out of 10 metropolitan areas analysed in this study. Smaller metropolitan areas have shown most increase with Ahmendad registering 4000 per cent jump in number of exceedances. Pune follows with 500 per cent incease and Japur 152 per cent increase (See *Graph 2: Change in ground-level ozone exceedances in ten major metropolitan areas of India*). Hyderabad registerd 115 per cent rise in number of exceedance days. Mumbai-MMR and Bengalure registed 18 per cent and 1 per cent increase respectively. Less

than 5 per cent change has been noted in Delhi-NCR and Lucknow. Meanwhile, Kolkata-KMA and Chennai have seen drop in number of exceedance by 19 per cent and 40 per cent respectively.

Graph 2: Change in ground-level ozone exceedances in ten major metropolitan areas of India



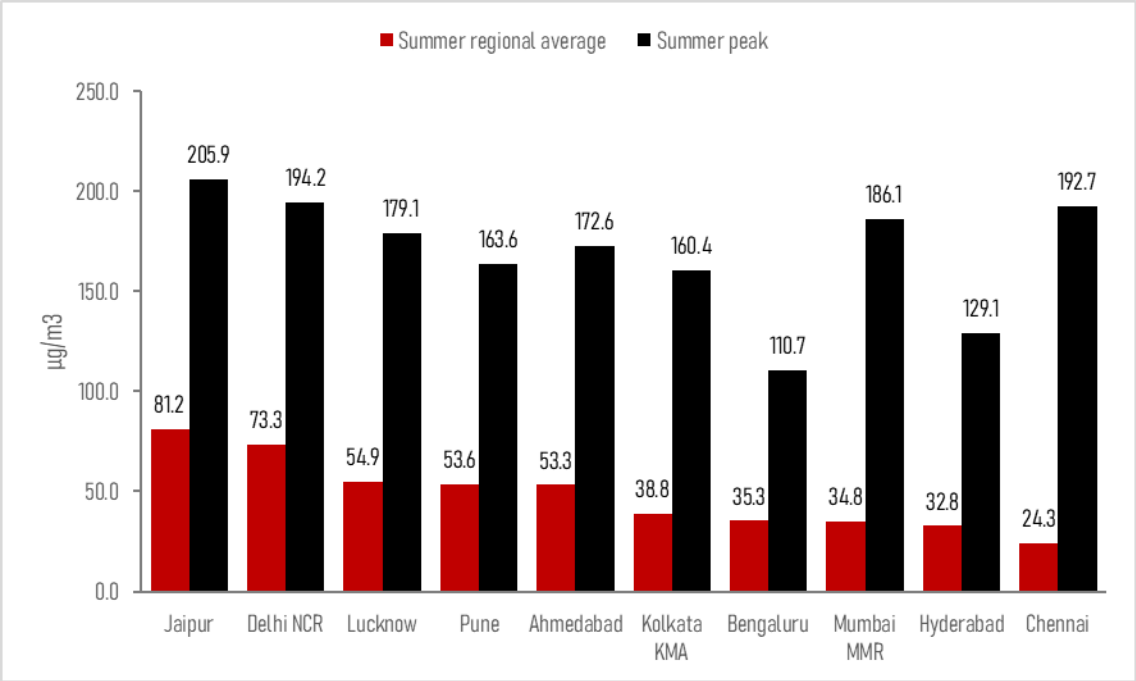
Note: Based on exceedances recorded at each monitoring stations of every city. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m^3. Data up till 18 July 2024.
Source: CSE analysis of CPCB realtime data.

Summer ground-level ozone peak is dangerously high in all ten metropolitan areas: Even though number of exceedance days is highest among Delhi-NCR and Mumbai-MMR (partly because they have highest number of stations) but from regional average concentration and peak level perspective Jaipur air is more toxic. The regional average of Jaipur for 1-April to 15-July is 81.2 µg/m3 compared to Delhi-NCR's 73.3 µg/m3 and Mumbai-MMR's 34.8 µg/m3 (See *Graph 3: Regional averages and peaks during the summer in ten major metropolitan areas of India*). Chennai has the lowest regional average of 24.3 µg/m3 but the peak recorded in the southern metro was 192.7 µg/m3, third highest among the 10 metropolitan areas only exceeded by Jaipur (205.9 µg/m3) and Delhi-NCR (194.2 µg/m3).

Mumbai-MMR's peak was fourth highest at 186.1 µg/m3. Lucknow had a regional average of 54.9 µg/m3 and regional peak of 179.1 µg/m3. Pune had a regional average of 53.6 µg/m3 and regional peak of 163.6 µg/m3. Ahmedabad had a regional average of 53.3 µg/m3 and regional peak of 172.6 µg/m3. Kolkata-KMA had a regional average of 38.8 µg/m3 and regional peak of 160.4 µg/m3. Bengaluru had a regional average of 35.3 µg/m3 and regional peak of 110.7 µg/m3 (lowest peak among the metropolitan areas). Hyderabad had a regional average of 32.8 µg/m3 and regional peak of 129.1 µg/m3.

Given the data cap of 200 µg/m3 enforced by CPCB at the 15-minute granularity, it is stunning to observe that multiple stations are still logging 8-hourly averages close to 200 µg/m3 across the country. This underscores the magnitude of the pollution.

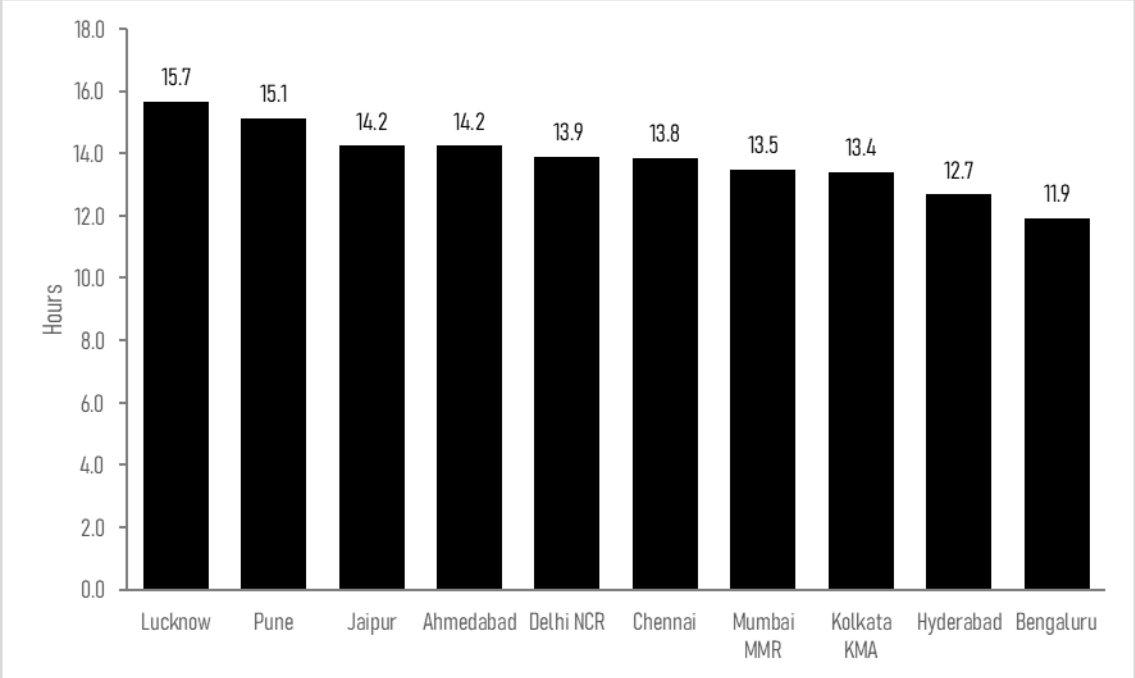
Graph 3: Regional averages and peaks during the summer in ten major metropolitan areas of India



Note: Based on exceedances recorded at each monitoring stations of every city. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Period of study is 1 April to 18 July 2024.
Source: CSE analysis of CPCB realtime data.

Duration of ground-level ozone pollution exceedance unhealtly long across all metropolitan areas, smaller metropolitan areas worst: Ground-level ozone exposure standand is defined in terms of 1-hourly average and 8-hourly average but it is noted that standard is breeched for much longer durations. This summer, at the stations which reported exceedance it lasted on average 11.9 hours in Bengaluru which was the lowest among the ten metropolitan areas while highest was in Lucknow where it lasted on average 15.7 hours. Average exceedance duration in Pune, Jaipur and Ahmedabad was 15.1 hours, 14.2 hours and 14.2 hours respectively (See *Graph 4: Average duration exceedance during summer among 10 major metropolitan areas of India*). Average duration ranged between 12 hours and 14 hours for Delhi-NCR, Mumbai-MMR, Chennai, Kolkata-KMA and Hyderabad.

Graph 4: Average duration exceedance during summer among 10 major metropolitan areas of India

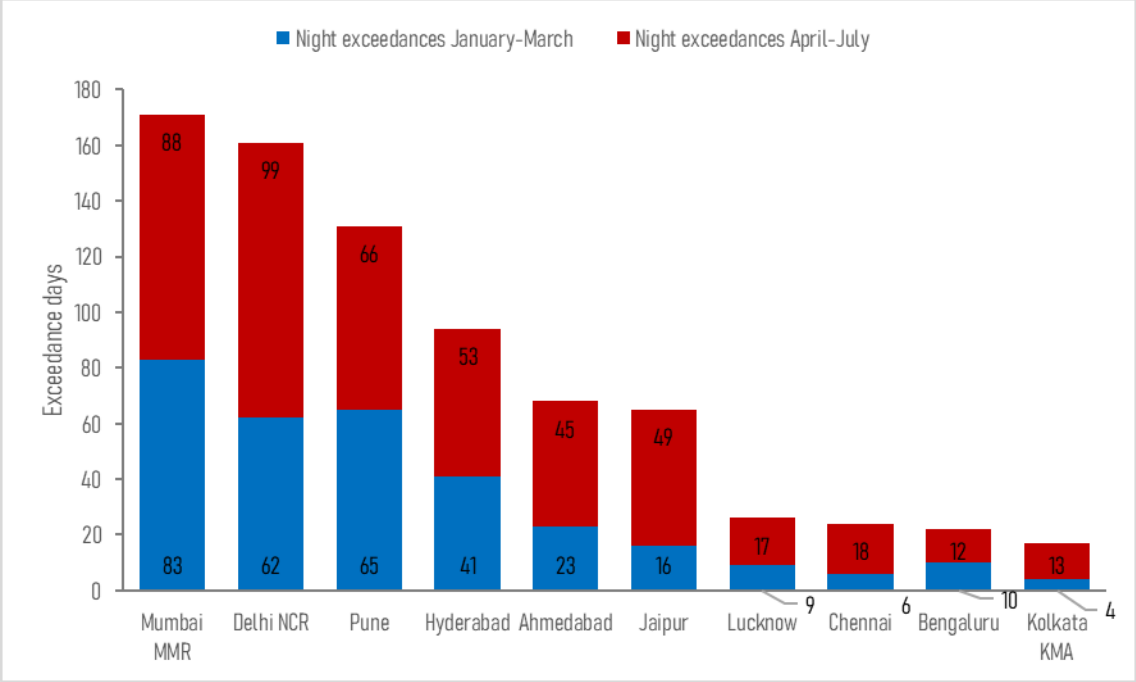


Note: Based on exceedances recorded at each monitoring stations of every city. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Duration of exceedance is computed as number of hours the rolling 8-hr average was exceeded at a station on a day. Period of the study is 1 April to 18 July. Source: CSE analysis of CPCB realtime data.

Night-time ground-level ozone continues to persist in all metropolitan areas: Ground-level ozone should ideally become negligible in the night air but all ten metropolitan areas have been witnessing a rare phenomenon where ozone levels remain elevated hours after sunset. Night-time ozone has been considered when hourly concentration has exceeded the level 100 µg/m³ between 10PM and 2AM at any station. Mumbai-MMR reported most instances of night-time ground-level ozone with 171 nights of exceedance. It is followed by Delhi-NCR and Pune with 161 nights and 131 nights respectively (See *Graph 4: Night-time ground-level ozone pollution among 10 major metropolitan areas of India*). Hyderabad recorded exceedance on 94 nights and Ahmedabad on 68 nights. Lucknow had 26 exceedance nights while Chennai had 24 exceedance nights. Bengaluru recoded 22 nights of exceedance. Least number of exceedance were recorded in Kolkata with just 17 nights.

Like daytime ground-level ozone exceedance, night-time exceedances are also recorded throughout January to July in all metropolitan areas. But unlike daytime exceedances there is no regional variation in the seasonality of night-time exceedances as all metropolitan areas record majorty of them during summer April-July.

Graph 4: Night-time ground-level ozone pollution among 10 major metropolitan areas of India



Note: Based on high hourly concentration of ground-level ozone recorded at each monitoring stations of every city during night-time. High hourly concentration is taken as 100 µg/m3 or more. Night-time is taken as 10PM to 2AM. Period of study is 1 April to 18 July 2024.
Source: CSE analysis of CPCB realtime data.

Ground-level ozone hotspots are located in the areas with low levels of NO2 and PM2.5: The spatial distribution of ground-level ozone is inverse of the NO2 and PM2. This bears out the fact that while ozone is created in polluted areas with nitrogen oxide being the catalyst, it also gets mopped up in high NO2 areas as it further reacts. But the ozone that escapes to cleaner areas with less NO2 builds up faster as unavailability of NO2 hampers its dissipation.

High end and green neighborhoods are worst affected by ground-level ozone pollution: Dr Karan Singh Shooting Range and Lodi Colony in Delhi, Navy Nagar in Mumbai, Fort William in Kolkata, Kapra in Hyderabad, BMT Layout in Bengaluru, Velachery in Chennai, Savitribai Phule University in Pune, Police Commissionerate in Jaipur, Gomti Nagar in Lucknow and Maninagar in Ahmedabad are all hotspots for ground-level ozone pollution.

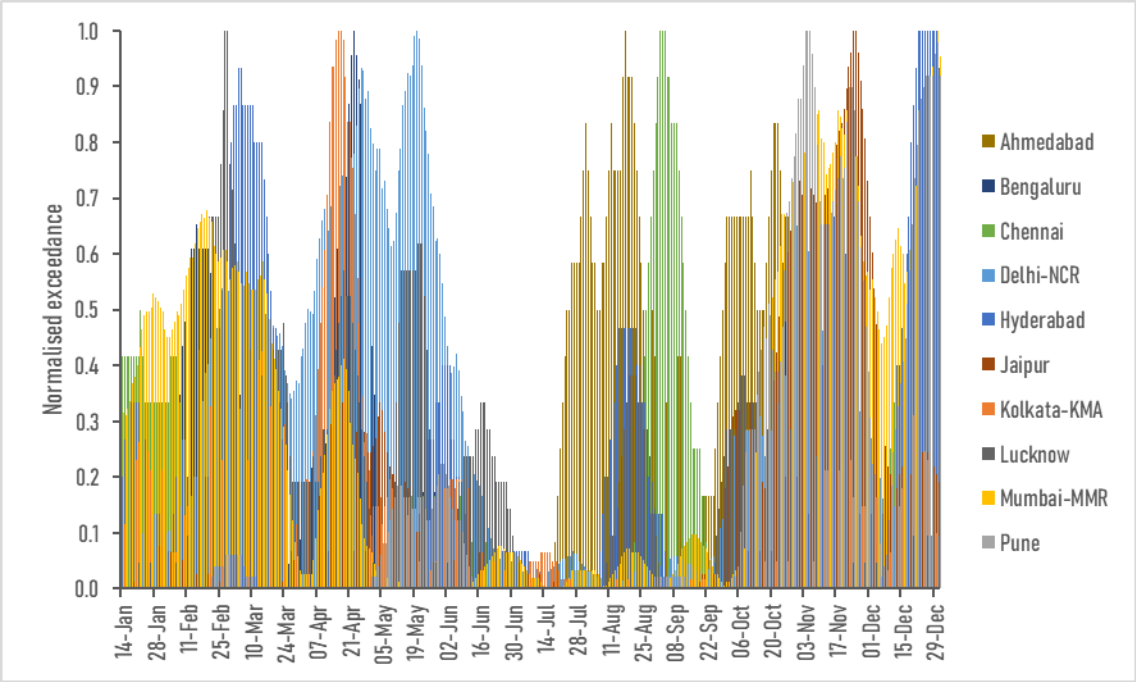
This is consistent with the science that ozone drifts and gathers in areas where comparativey lesser amount of gaseous pollutants are persent to further mop it up. Thus, relatively cleaner areas including urban peripheries can have comparatively higher ozone concentration.

Ground-level ozone has become a yearlong problem: Even though the ground-level ozone exceedance is assumed to be at its worst during summer months, but data from the 10 metropolitan areas analysed in the study show that ground-level ozone remains a year-long problem.

The intensity and spatial spread fall during non-summer days but at least few locations continue to record exceedance throughout the year. The dangerous build-up of ground-level

ozone can happen anytime during the year in the sunnier metropolitan areas of South India, but it is usually in small pockets during non-summer months. For it to have wider spatial spread hot and sunny weather conditions are needed which are generally present in summer – especially during April-May but there is a considerable uptick in ozone pollution after monsoon – especially October-November (See *Graph 5: Fortnightly trend in ground-level ozone among 10 major metropolitan areas of India for 2023*). Foggy and cold conditions of January in north India conventionally inhibit formation of ground-level ozone but ozone was found to be exceeding at multiple stations in Delhi.

Graph 5: Fortnightly trend in ground-level ozone among 10 major metropolitan areas of India for 2023



Note: Based on exceedances recorded at each monitoring stations of every city Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Duration of exceedance is computed as number of hours the rolling 8-hr average was exceeded at a station on a day. Period of the study is 1 April to 18 July.
Source: CSE analysis of CPCB realtime data.

Act now

This finding has a significant implcations for the NCAP programme that is currently focusing more on controlling PM10 or coarse dust. Immediately, refine the action strategy for combined control of particulate pollution, ozone and its precursor gases like NOx to maximise the co-benefits of the action plan. We need stringent control of precursor gases from vehicles, industry, cooking on solid fuels, open burning and other combustion sources while reducing PM2.5.

As ozone is a highly reactive and harmful gas simultaneously develop a robust public information and dissemination system to alert public about ozone exceedance wherever ozone build up is happening for exposure management.