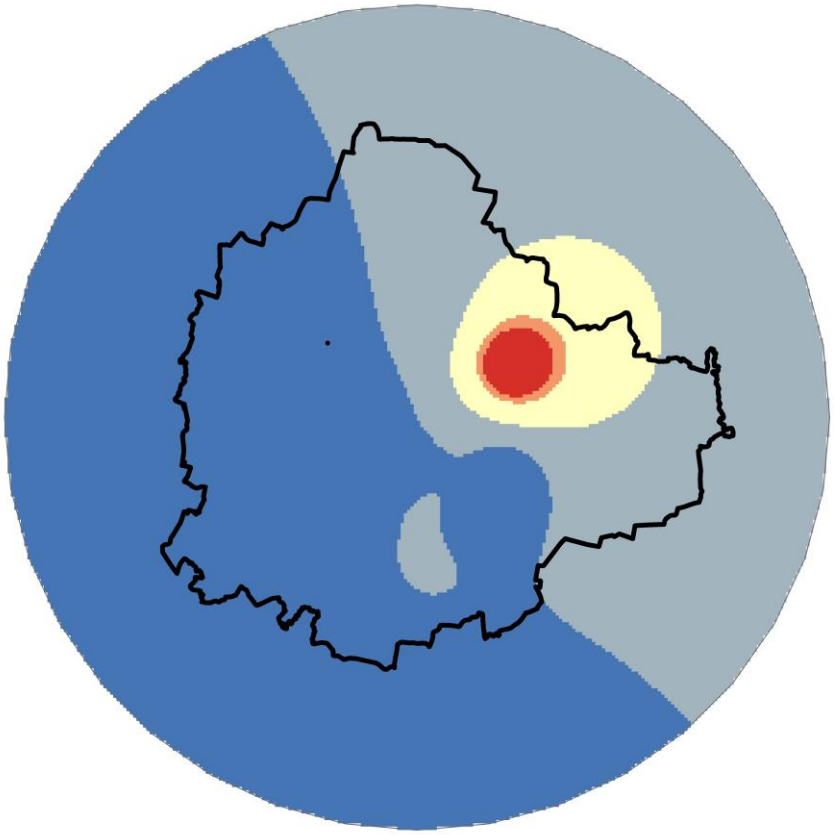
Air Quality Tracker

Ground-level Ozone



Bengaluru

Metropolitan Area

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Overview

Centre for Science and Environment (CSE) has alerted from time to time about the growing problem of ground-level ozone in Indian cities. 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 of Mumbai and larger MMR even more toxic. This summer the geographical spread of the problem is even more wide spread as compared to last summer. The toxic built up is not lasting as long at locations where it is happening this summer compared to previous summers.

Health evidence is also growing stronger. 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 in different cities and regions to inform mitigation.

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. Compliance requires that the 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 Central Pollution Control Board 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.

Global experience shows that there is usually a trade-off. As particulate pollution is reduced the problem of NOx and ground-level ozone increase. Globally, regulators are tightening the regulatory benchmark for ozone to address the toxic threat which – given its complex chemistry, is difficult to address. India should prevent this trap.

Why ozone needs special attention? Complex chemistry of ground-level ozone makes it a difficult pollutant to track and mitigate. 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. Ozone not only builds up in cities but also drifts long distances to form a regional pollutant that makes both local and regional action necessary.

This highly reactive gas has serious health consequences. 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 investigation: This assessment has traced trends in ground-level ozone data 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 14 official stations under the Continuous Ambient Air Quality Monitoring System (CAAQMS) spread across Greater Bengaluru Metropolitan Area.

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.

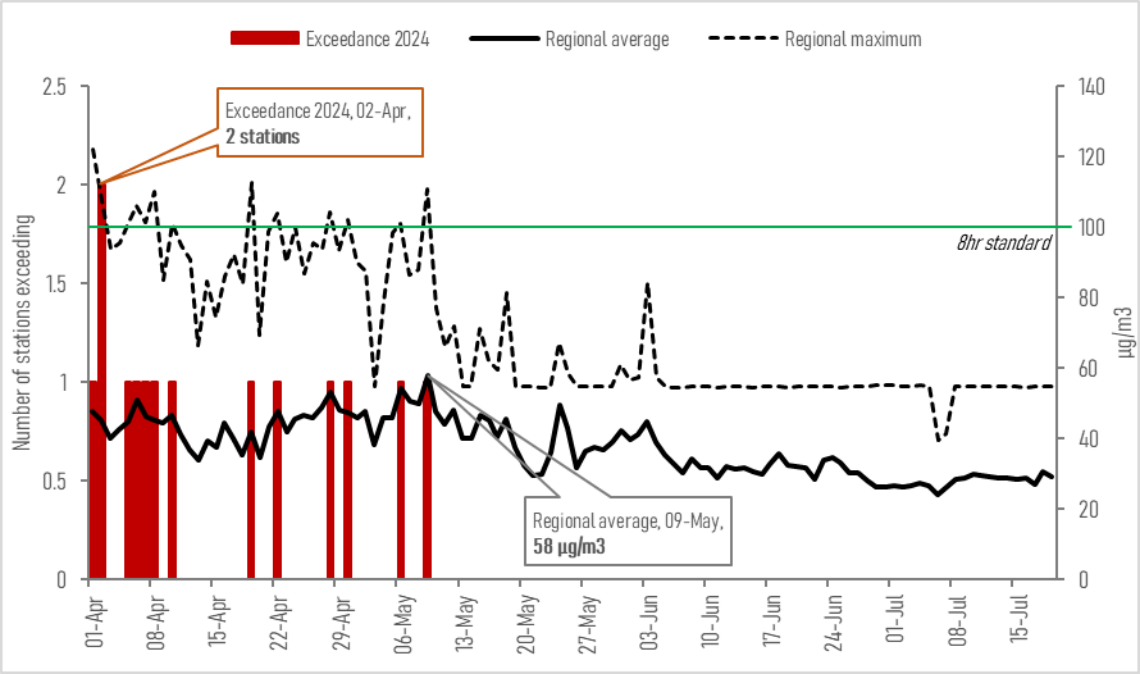
The study has considered global good practice and taken on board the USEPA approach of computing eight-hour averages for a day and then checking for the maximum value among them to capture the daily ozone pollution level. USEPA assesses city-wide or regional AQI based on the highest value recorded among 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 findings

Ground-level ozone exceedance is reported on 13 days of this summer: This summer ground-level ozone exceedances were reported on 13 days between 1 April and 18 July. The worst day of ground ozone pollution was on 2 April when 2 stations out of 14 stations of Greater Bengaluru reported exceedance (See *Graph 1: Daily variation in ground-level ozone exceedance in Bengaluru Metropolitan Area*). It should be noted that exceedance was higher in March than in summer. The intensity of pollution was worst on 9 May when the regional average reached 58 µg/m3.

Graph 1: Daily variation in ground-level ozone in Bengaluru Metropolitan Area

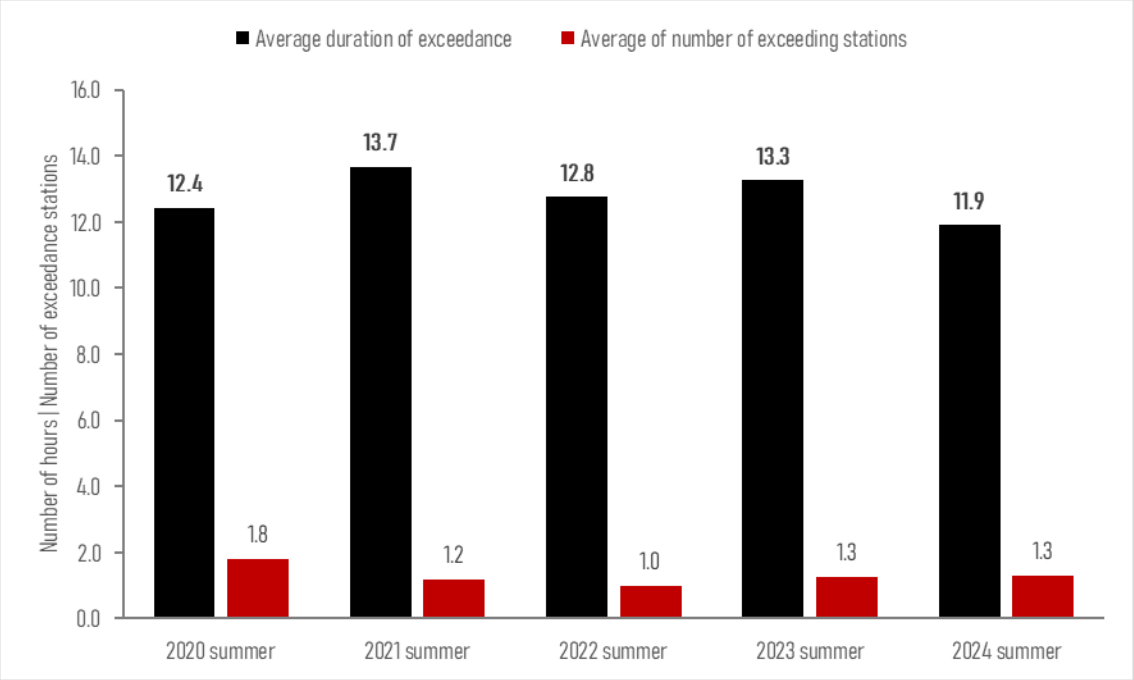


Note: Based on exceedances recorded at the monitoring stations at Bengaluru Metropolitan Area. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Period of study is 1 April to 18 July 2024.
Source: CSE analysis of CPCB realtime data.

Geographical spread of ground-level ozone pollution in Bengaluru Metropolitan Area is relatively lesser this year: Ground-level ozone usually exceeds the safety standard on all days of summer in some location in Greater Bengaluru every year. This year the spatial spread (number of stations exceeding the standard across Greater Bengaluru) has been 1.3 stations per day for period 1 January to 30 June. On an average 1.8 stations used to exceed the standard daily during the 2020 summers (See *Graph 2: Variation in average duration and spatial spread of daily exceedance in Bengaluru Metropolitan Area*).

Average duration of exceedance this year has been the lowest in last five years. This year so far, at the stations which reported exceedance it lasted on average 11.9 hours, it was 13.3 hours in the previous year.

Graph 2: Variation in average duration and spatial spread of exceedance in Bengaluru



Note: Based on exceedances recorded at the monitoring stations in Bengaluru Metropolitan Area. 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 January to 30 June.
Source: CSE analysis of CPCB realtime data.

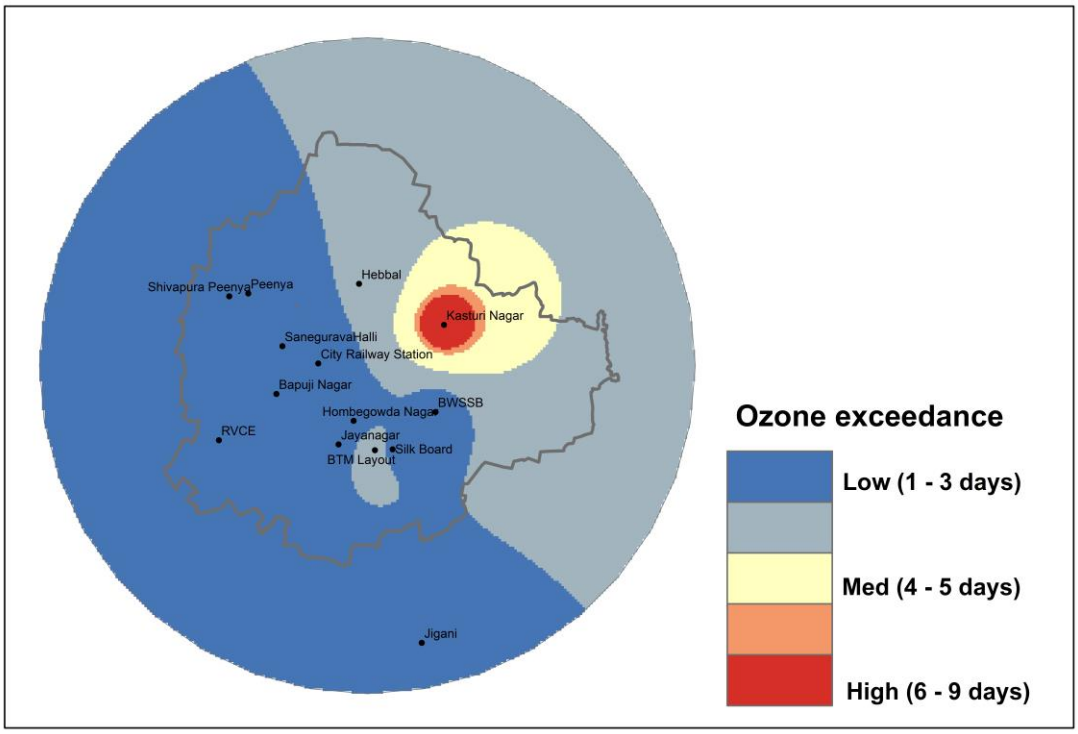
Kasturi Nagar and Shivapura Peenya are the worst affected by ground-level ozone pollution in Bengaluru Metropolitan Area: Kasturi Nagar in the outer Bengaluru is the most chronically affected by ground ozone pollution in Greater Bengaluru. It has exceeded the standard in this location for 49 days this year so far. It is followed by Shivapura Peenya and Peenya as the worst polluted with 13 days and 6 days of exceedance respectively (See *Map 1: Hotspots of ground-level ozone exceedance in Bengaluru Metropolitan Area* & *Table 1: Locations with most ground-level ozone exceedance in Bengaluru Metropolitan Area*). Jayanagar, Bapuji Nagar and Silk Board have least instances of ground-level ozone exceedances in the region.

Table 1: Locations with most ground-level ozone exceedance in Bengaluru Metropolitan Area

S.No.	Station	Number of exceedance days
1	Kasturi Nagar, Bengaluru	49
2	Shivapura Peenya, Bengaluru	13
3	Peenya, Bengaluru	6
4	BTM Layout, Bengaluru	5
5	Jigani, Bengaluru	2
6	Hebbal, Bengaluru	1
7	Bapuji Nagar, Bengaluru	0
8	Hombegowda Nagar, Bengaluru	0
9	Jayanagar, Bengaluru	0
10	Silk Board, Bengaluru	0
11	RVCE, Bengaluru	0
12	BWSSB, Bengaluru	
13	City Railway Station, Bengaluru	
14	Saneguruva Halli, Bengaluru	

Note: 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 January to 18 July 2024. Source: CSE analysis of CPCB realtime data.

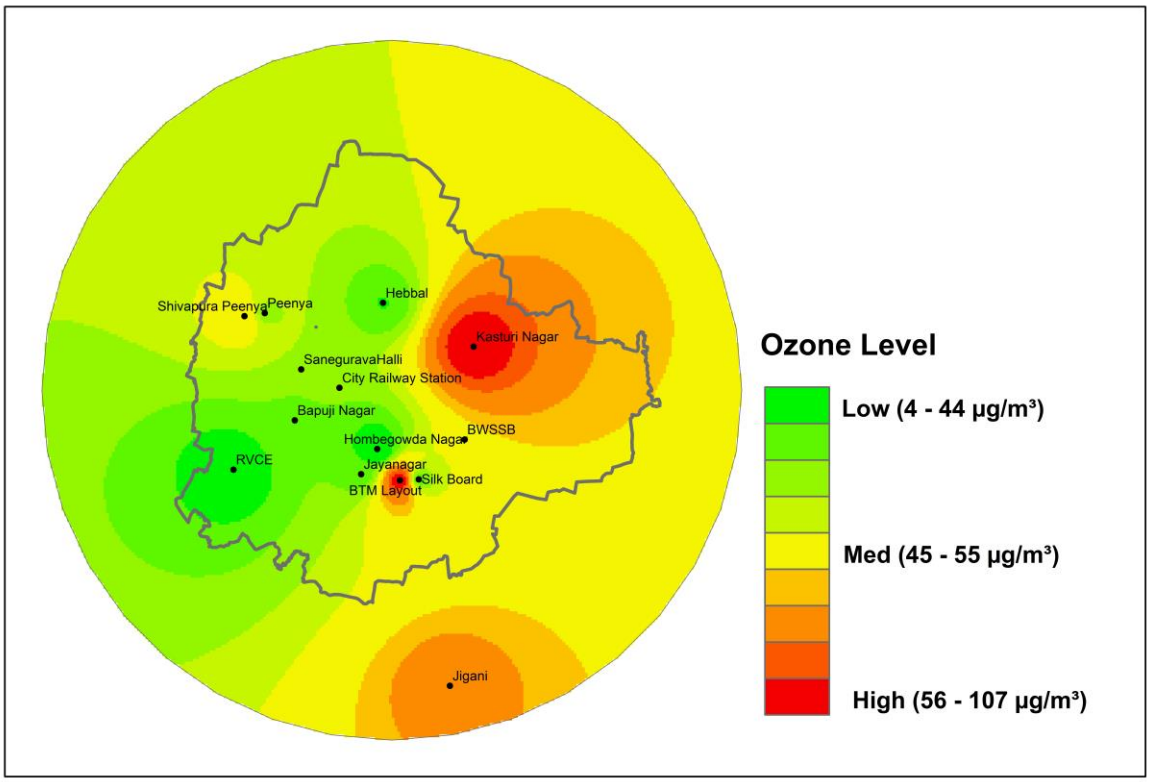
Map 1: Hotspots of ground-level ozone exceedance in Bengaluru Metropolitan Area

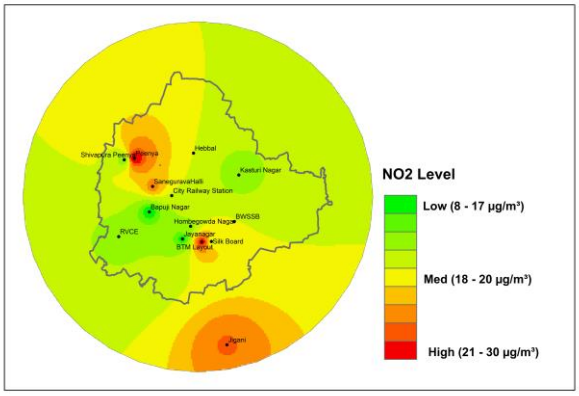


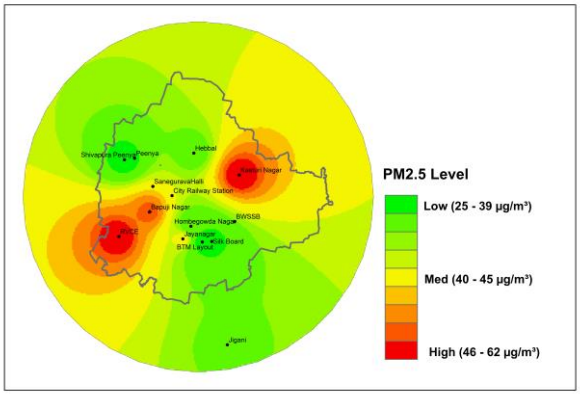
Note: Based on exceedances recorded at the monitoring stations in Bengaluru Metropolitan Area. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Period of study is 1 April to 18 July 2024.
Source: CSE analysis of CPCB realtime data.

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 PM2.5 (see *Map 2: Spatial relationship among hotspots for key pollutants in Bengaluru Metropolitan Area*). 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. Peenya is exception to this phenomena as these stations report both high NO2 and ground-level ozone.

Map 2: Spatial relationship among hotspots for key pollutants in Bengaluru







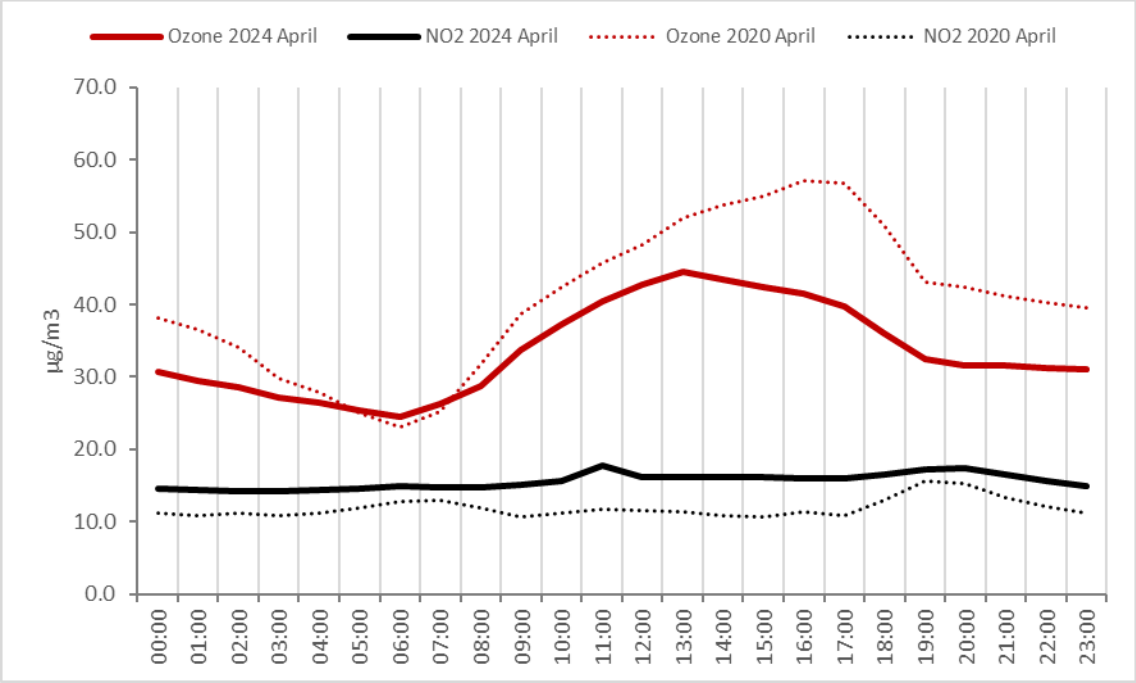
Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for PM2.5 and NO2, while daily maximum 8-hr average is used for ground-level ozone. Period of study is 1 April to 18 July 2024.
Source: CSE analysis of CPCB realtime data.

Regional hourly ozone peak level is down by 20 per cent compared to lockdown times: Since CPCB caps the data at 200 µg/m^3 it is not possible to access precisely how high the ground-level ozone concentration can go up to, but for to get a relative understanding in this study hourly data averaged across all station and all days of April has been analysed. This indicative analysis shows that compared to April of 2020 ground-level ozone hourly peak on an average has gone down up by 20 per cent (See *Graph 3: Hourly cycle of ground level ozone and NO2 in Bengaluru Metropolitan Area – April 2020 v/s April 2024*). The re-emergence of morning

and evening rush-hour traffic is helping in neutralising ground-level ozone at sunrise and sunset as increased NO2 levels cannibalise it.

The maximum 8-hour average was recorded at Shivapura Peenya, Bengaluru when level hit 160.5 µg/m^3 on 21 January 2024. It was followed by Kasturi Nagar and Peenya (See *Table 2: Highest peak ground-level ozone pollution recorded in Bengaluru Metropolitan Area*). Given the data cap of 200 µg/m^3 enforced by CPCB at the 15-minute granularity, this underscores the magnitude of the pollution.

Graph 3: Hourly cycle of ground-level ozone and NO2 in Bengaluru–April 2020 v/s 2024



Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations in Bengaluru Metropolitan Area for month of April in 2020 and 2024. Period of study is 1 April to 18 July 2024.
Source: CSE analysis of CPCB realtime data.

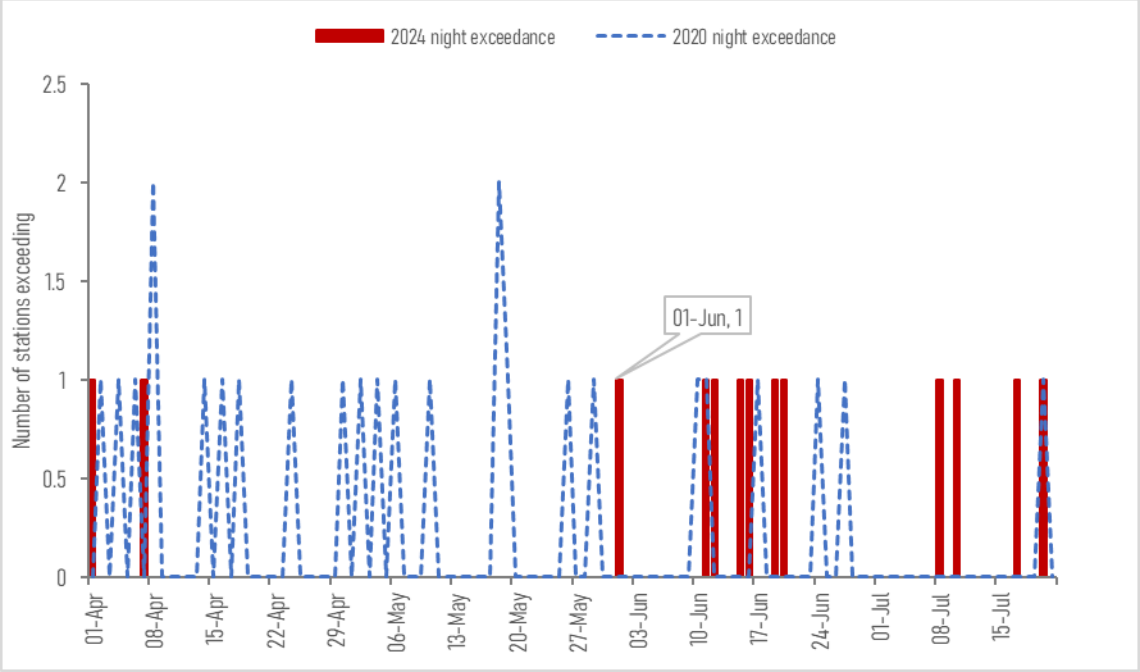
Table 2: Highest peak ground-level ozone pollution recorded in Bengaluru Metropolitan Area

S.No.	Station	Highest daily 8-hr average in µg/m^3
1	Shivapura Peenya, Bengaluru	160.5
2	Kasturi Nagar, Bengaluru	147.1
3	Peenya, Bengaluru	139.1
4	Jigani, Bengaluru	116.0
5	Hebbal, Bengaluru	110.7
6	BTM Layout, Bengaluru	105.7
7	Hombegowda Nagar, Bengaluru	81.7
8	RVCE, Bengaluru	70.0
9	Jayanagar, Bengaluru	56.5
10	Bapuji Nagar, Bengaluru	52.6
11	Silk Board, Bengaluru	48.5
12	BWSSB, Bengaluru	
13	City Railway Station, Bengaluru	
14	Saneguruva Halli, Bengaluru	

Note: Based on daily maximum 8-hr average. Period of study is 1 January to 18 July 2024. Source: CSE analysis of CPCB realtime data.

Night-time ground-level ozone continues to persist: Ground-level ozone should ideally become negligible in the night air but Bengaluru Metropolitan Area has been witnessing a rare phenomenon where ozone levels remain elevated hours after sunset. This was found to be very wide-spread in Delhi during the lockdowns of 2020 summers but it is now been noted in Bengaluru Metropolitan Area this year as well. This night-time ozone was noted at 0.1 stations on average every night (See *Graph 4: Daily variation in occurrence of high night-time ground-level ozone pollution*). It was 0.3 stations per night during the 2020 summer. Night-time ozone has been considered when hourly concentration has exceeded the level 100 µg/m^3 between 10PM and 2AM at any station. Night-time ozone is most frequently in Bapuji Nagar where it was reported on 9 nights (See *Table 5: Locations with most night-time ground-level ozone pollution instances*).

Graph 4: Daily variation in occurrence of high night-time ground-level ozone pollution



Note: Based on high hourly concentration of ground-level ozone recorded at the monitoring stations in Bengaluru Metropolitan Area 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.

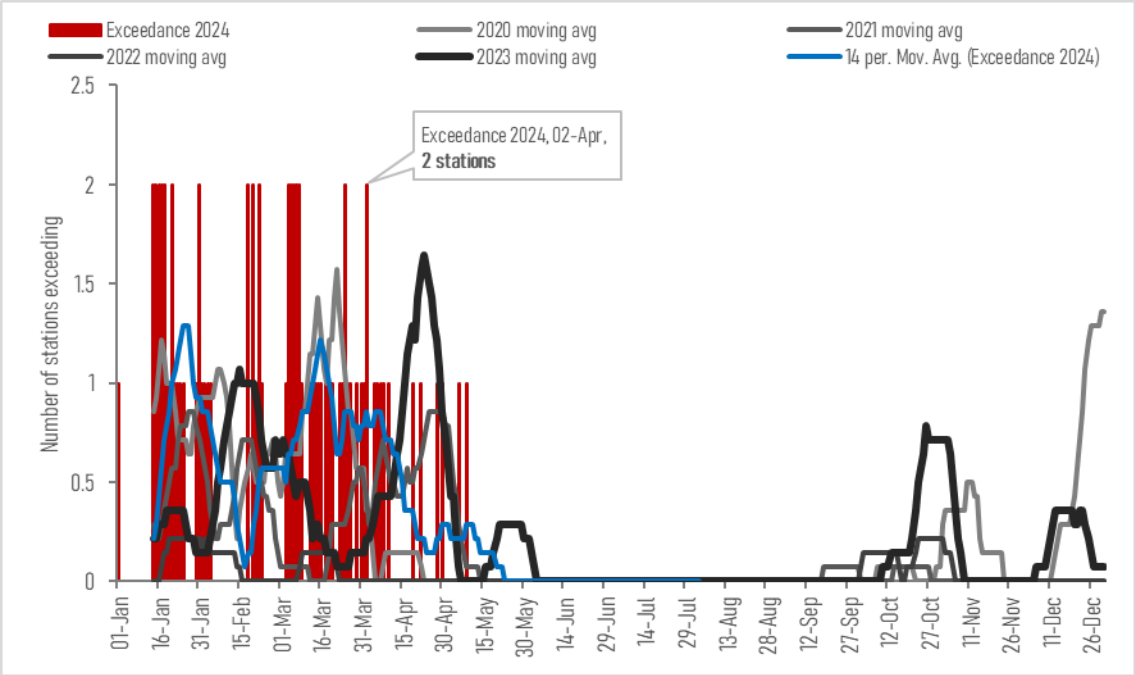
Ground-level ozone has become a yearlong problem: Even though the ground-level ozone exceedance is the worst during summer months, it remains a year-long problem as at least few locations continue to record exceedance throughout the year. The dangerous build-up of ground-level ozone can happen anytime during the year, 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 Bengaluru Metropolitan Area throughout the year outside monsoon. Ground ozone pollution in Greater Bengaluru is at its worse during January-March. Exceedances go down from May onwards and then there is a considerable uptick in ozone pollution after monsoon – especially November-December (See *Graph 5: Trend in ground-level ozone over years -2020-24*). On the annual scale, last year exceedance were reported on 67 days, they were 12 days in 2022, 48 days in 2021, and 61 days in 2020. This year so far 59 days of exceedance have been recorded in Bengaluru Metropolitan Area.

Table 5: Locations with most night-time ground-level ozone pollution instances

S.No.	Station	Number of night-time exceedance
1	Bapuji Nagar, Bengaluru	9
2	Hebbal, Bengaluru	3
3	Silk Board, Bengaluru	3
4	BTM Layout, Bengaluru	2
5	Jayanagar, Bengaluru	2
6	Shivapura Peenya, Bengaluru	2
7	Peenya, Bengaluru	1
8	Jigani, Bengaluru	1
9	RVCE, Bengaluru	1
10	Hombegowda Nagar, Bengaluru	0
11	Kasturi Nagar, Bengaluru	0
12	BWSSB, Bengaluru	
13	City Railway Station, Bengaluru	
14	Saneguruva Halli, Bengaluru	

Note: Based on high hourly concentration of ground-level ozone recorded 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.

Graph 5: Trend in ground-level ozone over years -2020-24



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Source: CSE analysis of CPCB realtime data.

Act now

Ozone mitigation demands stringent control of gases from all combustion sources including vehicles, industry, power plants and open burning in the entire region. It is therefore necessary that while designing mitigation of particulate matter the key focus of action strategy today, is also calibrated for reduction of ozone precursor gases.

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.

Simultaneously develop a robust public information and dissemination system to alert public about ozone exceedance wherever ozone build up is happening for exposure management.