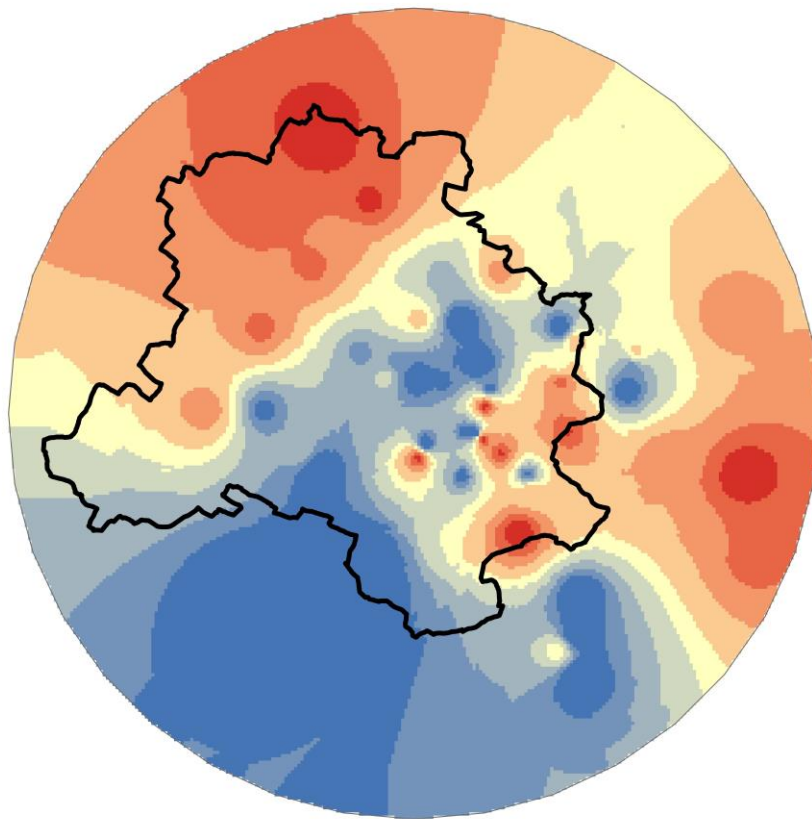




# **Air Quality Tracker**

## **Ground-level Ozone**



# **Delhi**

## **National Capital Region**



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# Overview

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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 Delhi-NCR even more toxic. This summer the geographical spread of the problem is even more wide spread than observed during lockdown summer of 2020. The toxic built up is lasting much longer this summer at locations where it is happening.

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 breached, 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 NO<sub>x</sub> 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 (NO<sub>x</sub>) 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 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 58 official stations under the Continuous Ambient Air Quality Monitoring System (CAAQMS) spread across Delhi-NCR. Delhi (40), Gurugram (4), Faridabad (4), Noida (4), Ghaziabad (4), and Greater Noida (2).

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 µg/m<sup>3</sup> by CPCB, it is not possible to determine how high the concentration really goes.

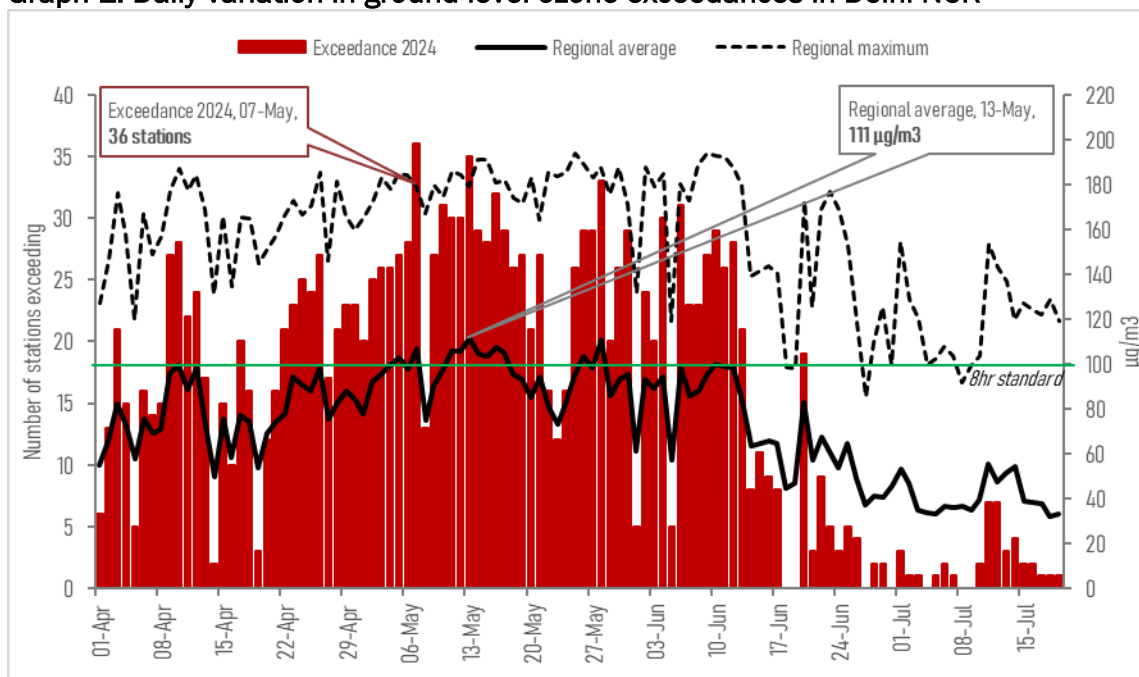
The study has considered global good practice and taken on board the USEPA approach of computing eight-hour averages for a day and then checking for the maximum value among them to capture the daily ozone pollution level. USEPA assesses city-wide or regional AQI based on the highest value recorded among 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 µg/m<sup>3</sup>, 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 µg/m<sup>3</sup> and one hourly standard at 180 µg/m<sup>3</sup>. Capping makes assessment of one-hourly standard challenging.

# Key highlights

**Ground-level ozone exceedance is reported on nearly all days of this summer:** This summer ground-level ozone exceedances were reported on 102 days between 1 April and 18 July. The worst day from spatial spread of ground ozone was the 7th of May when 36 stations out of 59 stations of Delhi-NCR reported exceedance (See *Graph 1: Daily variation in ground-level ozone exceedance in Delhi-NCR*). Nevertheless intensity of pollution was highest on 28<sup>th</sup> May when the regional average stood at 111  $\mu\text{g}/\text{m}^3$ .

**Graph 1: Daily variation in ground-level ozone exceedances in Delhi-NCR**



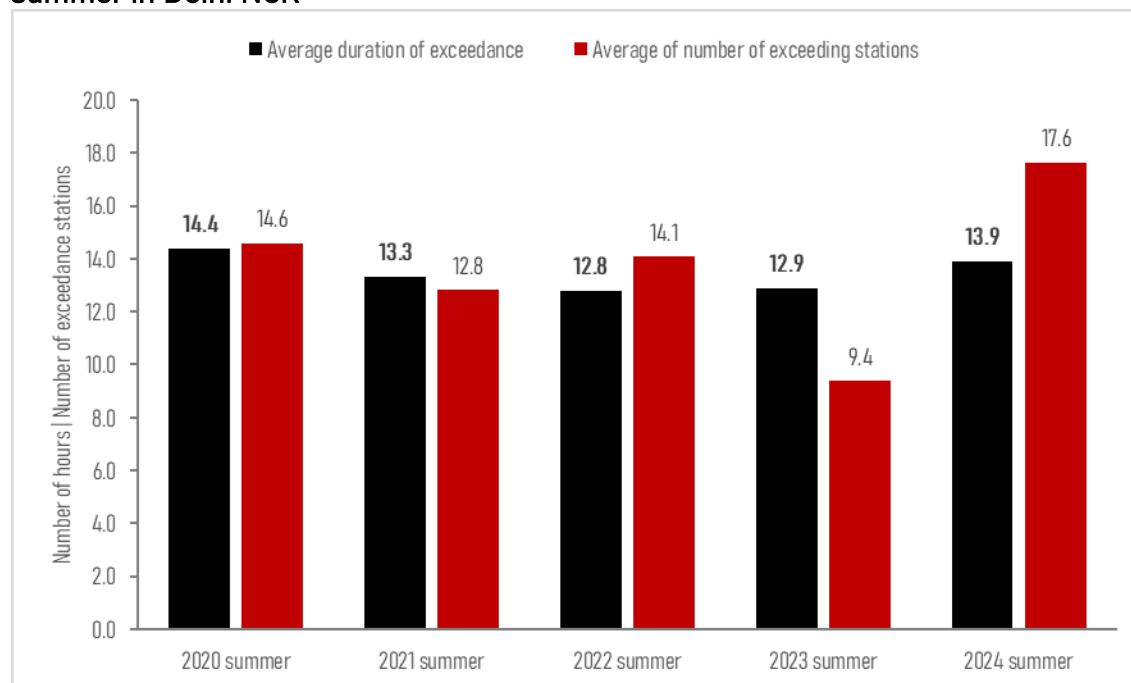
Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100  $\mu\text{g}/\text{m}^3$ . Period of study is 1 April to 18 July 2024.

Source: CSE analysis of CPCB realtime data.

**Geographical spread of ground-level ozone pollution in Delhi-NCR this summer is the largest in past 5 years:** Ground-level ozone usually exceeds the safety standard on all days of summer in some location in Delhi-NCR every year. This year the spatial spread (number of stations exceeding the standard across the core NCR) has been 17.6 which is the highest in last five years. On an average only 9.4 stations were exceeding the standard daily during the previous summer and 14.6 stations during the 2020 summer (See *Graph 2: Variation in average duration and spatial spread of daily exceedance during summer in the core Delhi-NCR*).

Not just the spatial spread of ground-level ozone has increased this summer, but also its duration has increased. This summer, at the stations which reported exceedance it lasted on average 13.9 hours, which is highest since the pandemic summer of 2020.

**Graph 2: Variation in average duration and spatial spread of daily exceedance during summer in Delhi-NCR**



Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e.  $100 \mu\text{g}/\text{m}^3$ . 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.

### **New Delhi and South Delhi neighborhoods are worst affected by ground-level ozone pollution:**

Dr Karan Singh Shooting Range in south Delhi is the most chronically affected by ground ozone pollution in Delhi-NCR. It has exceeded the standard in this location for 78 days this summer. It is followed by Narela, Greater Noida and JLN Stadium as the worst polluted (See *Map 1: Hotspots of ground-level ozone exceedance in the core Delhi-NCR* & *Table 1: Locations with most ground-level ozone exceedance in the core Delhi-NCR*). Faridabad and Gurugram have least instances of ground-level ozone exceedances in the region (See *Table 2: Locations with the lowest ground-level ozone pollution in the core Delhi-NCR*).

**Table 1: Locations with most ground-level ozone exceedance in the core Delhi-NCR**

SNo	Station	Number of exceedance days
1	Dr Karan Singh Shooting Range, Delhi	78
2	Narela, Delhi	78
3	Knowledge Park-V, Greater Noida	75
4	JLN Stadium Delhi	71
5	Alipur, Delhi	69
6	RK Puram Delhi	69
7	National Stadium Delhi	68
8	Nehru Nagar, Delhi	67
9	Sector 1, Noida	66
10	Bawana, Noida	63

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e.  $100 \mu\text{g}/\text{m}^3$ . Period of study is 1 April to 18 July 2024.

Source: CSE analysis of CPCB realtime data.

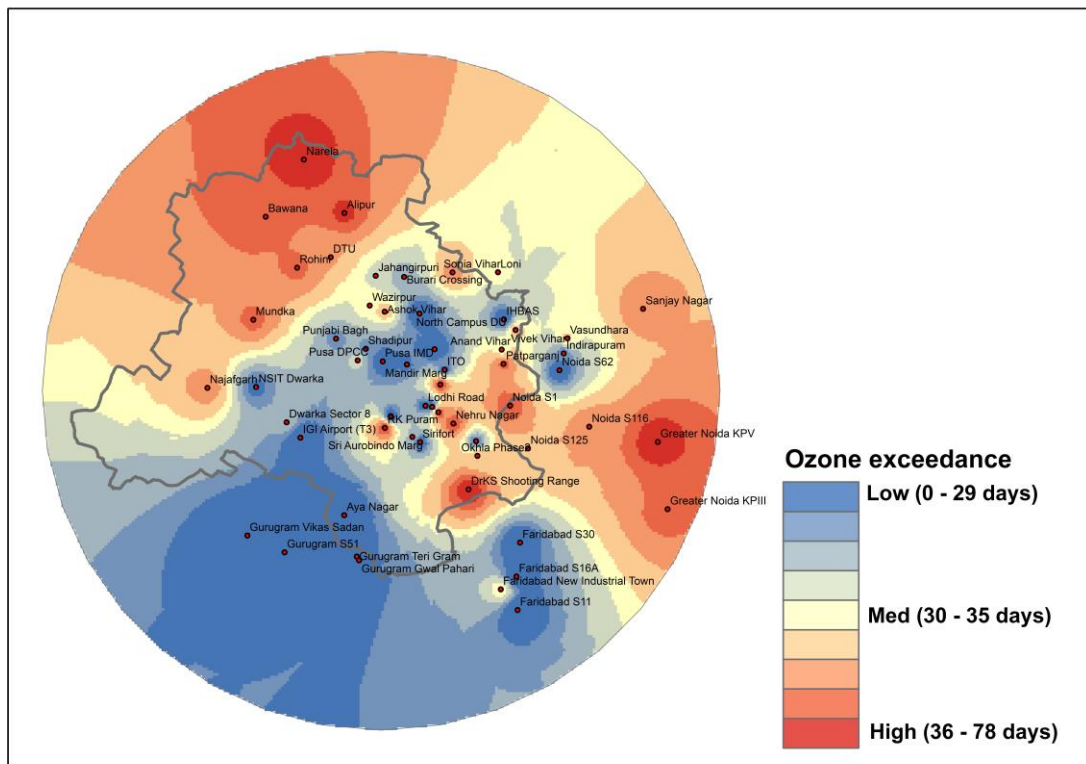
**Table 2: Locations with the lowest ground-level ozone pollution in the core Delhi-NCR**

SNb.	Station	Number of exceedance days
1	Aya Nagar, Delhi	0
2	Chandni Chowk, Delhi	0
3	IGI Airport T3, Delhi	0
4	IHBAS, Delhi	0
5	Pusa, Delhi	0
6	Sector 11, Faridabad	0
7	Sector 16A, Faridabad	0
8	Sector 51, Gurugram	0

Note: No exceedance was recorded among these stations. Ranking is based on daily maximum 8-hr average. Period of study is 1 April to 18 July 2024.

Source: CSE analysis of CPCB realtime data.

**Map 1: Hotspots of ground-level ozone exceedance in the core Delhi-NCR**



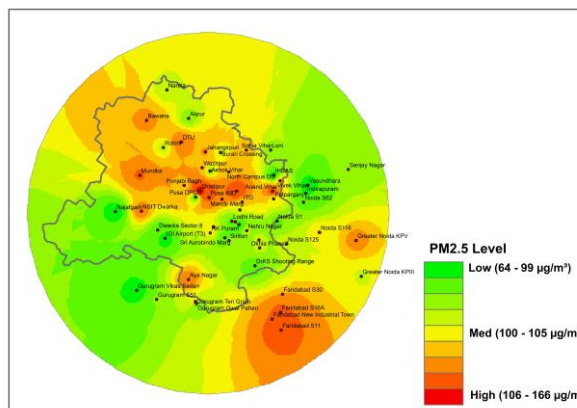
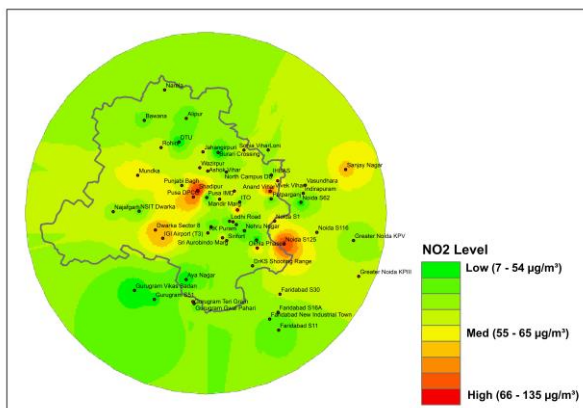
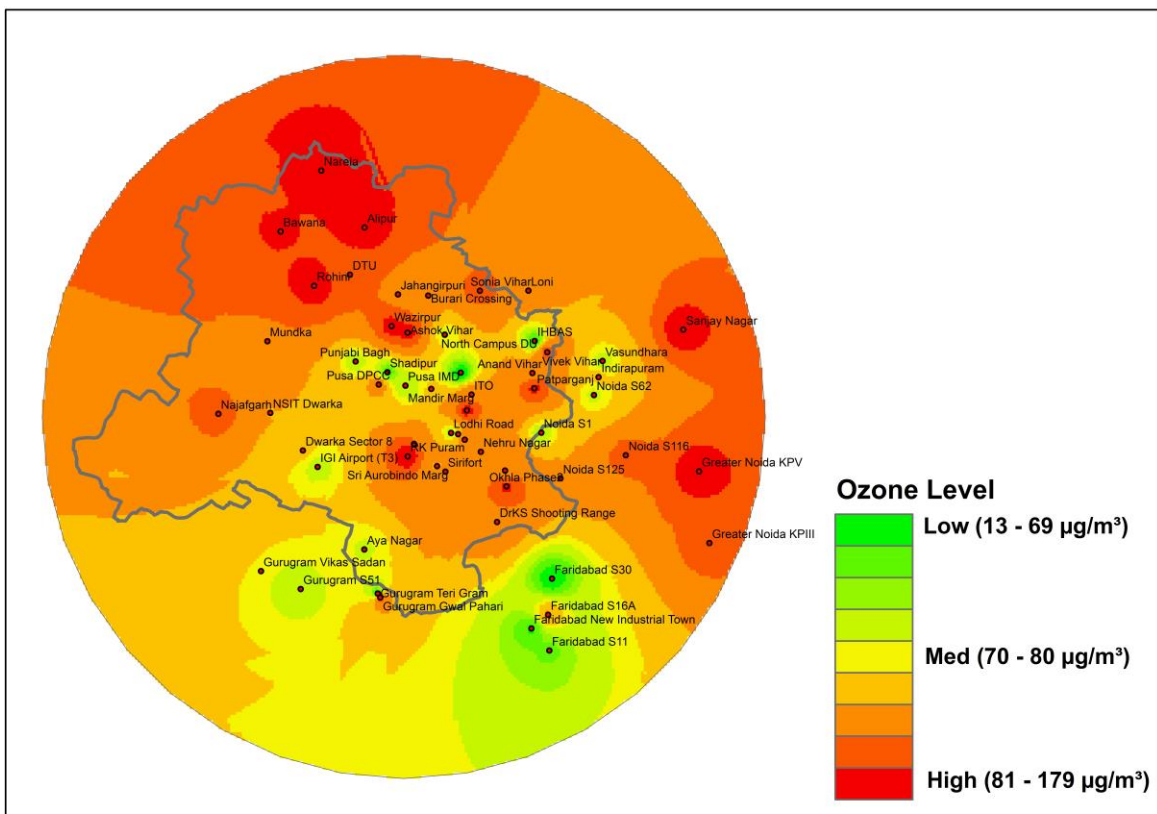
Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m<sup>3</sup>. Period of study is 1 April to 18 July 2024.

Source: CSE analysis of CPCB realtime data.



**Ground-level ozone hotspots are located in the areas with low levels of NO<sub>2</sub> and PM<sub>2.5</sub>:** The spatial distribution of ground-level ozone is inverse of the NO<sub>2</sub> and PM<sub>2.5</sub> (see *Map 2: Spatial relationship among hotspots for key pollutants in the core Delhi-NCR*). 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 NO<sub>2</sub> areas as it further reacts. But the ozone that escapes to cleaner areas with less NO<sub>2</sub> builds up faster as unavailability of NO<sub>2</sub> hampers its dissipation.

**Map 2: Spatial relationship among hotspots for key pollutants in Delhi-NCR**



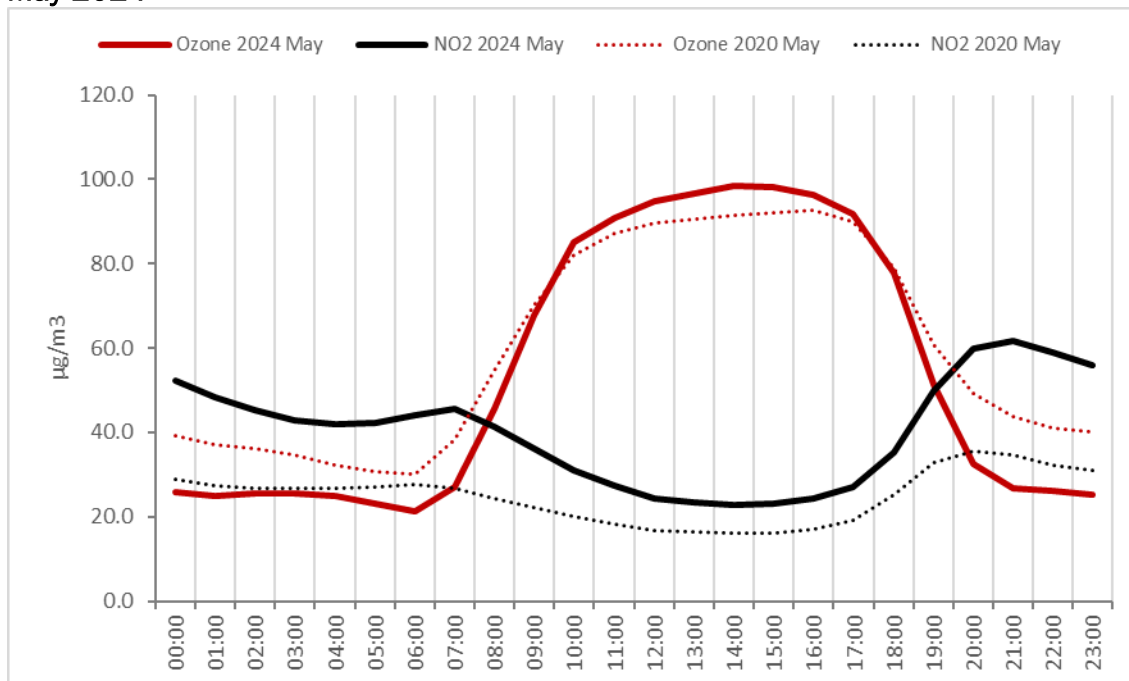
Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for PM<sub>2.5</sub> and NO<sub>2</sub>, while daily maximum 8-hr average is used for ground-level ozone. Period of study is 1 April to 18 July 2024.  
 Source: CSE analysis of CPCB realtime data.

**Regional hourly ozone peak level is up by 6 per cent compared to lockdown times:** Since CPCB caps the data at 200  $\mu\text{g}/\text{m}^3$  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 May has been analysed. This indicative analysis shows that compared to May of 2020 ground-level ozone is not lingering in the air post sunset but the hourly peak is also on an average up by 6 per cent (See *Graph 3: Hourly cycle of ground level ozone and NO<sub>2</sub> in the core Delhi-NCR – May 2020 v/s May 2024*). The re-emergence of morning and evening rush-hour traffic is helping in neutralising ground-level ozone at sunrise and sunset as increased NO<sub>2</sub> levels cannibalise it.

The maximum 8-hour average at Alipur in Delhi hit 194.1  $\mu\text{g}/\text{m}^3$  on 9 June 2024. Three more stations broke 190  $\mu\text{g}/\text{m}^3$  mark this summer namely, Rohini, Ashok Vihar and Dr K S Shooting Range. Knowledge Parks in Greater Noida are peak hotspots outside Delhi (See *Table 3: Locations with the highest daily peak ground-level ozone pollution in the core Delhi-NCR*).

Given the data cap of 200  $\mu\text{g}/\text{m}^3$  enforced by CPCB at the 15-minute granularity, it is stunning to observe that multiple stations are still logging 8-hourly averages exceeding 180  $\mu\text{g}/\text{m}^3$  every year. This underscores the magnitude of the pollution.

**Graph 3: Hourly cycle of ground-level ozone and NO<sub>2</sub> in the core Delhi-NCR – May 2020 v/s May 2024**



Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO<sub>2</sub> recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida for month of May in 2020 and 2023. Period of study is 1 April to 18 July 2024. Source: CSE analysis of CPCB realtime data.

**Table 3: Locations with highest daily peak ground-level ozone pollution in the core Delhi-NCR**

SNb	Station	Highest daily 8-hr average in $\mu\text{g}/\text{m}^3$
1	Alipur, Delhi	194.1
2	Rohini, Delhi	191.0
3	Ashok Vihar, Delhi	190.9
4	Dr KS Shooting Range, Delhi	190.1
5	JLN Stadium, Delhi	188.8
6	Bawana, Delhi	187.6
7	Knowledge Park-III, Greater Noida	187.6
8	Nehru Nagar, Delhi	187.5
9	Patparganj, Delhi	187.1
10	Sector 1, Noida	186.0

Note: Based on daily maximum 8-hr average. Period of study is 1 April 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 Delhi-NCR has been witnessing a rare phenomenon where ozone levels remain elevated hours after sunset. This was found to be very wide-spread during the lockdowns of 2020 summers and it continues to linger this summer as well. This summer night-time ozone was noted at 5 stations on average every night (See *Graph 4: Variation in occurrence of high night-time ground-level ozone pollution*). It was 7.7 stations per night during the 2020 summer. Night-time ozone has been considered when hourly concentration has exceeded the level  $100 \mu\text{g}/\text{m}^3$  between 10PM and 2AM at any station. Night-time ozone is most frequently in Dr K S Shooting Range in South Delhi where it was reported on 42 nights this summer. Outside Delhi, the most nighttime ozone is reported in Vasundhara in Ghaziabad (See *Table 5: Locations with most night-time ground-level ozone pollution instances*).

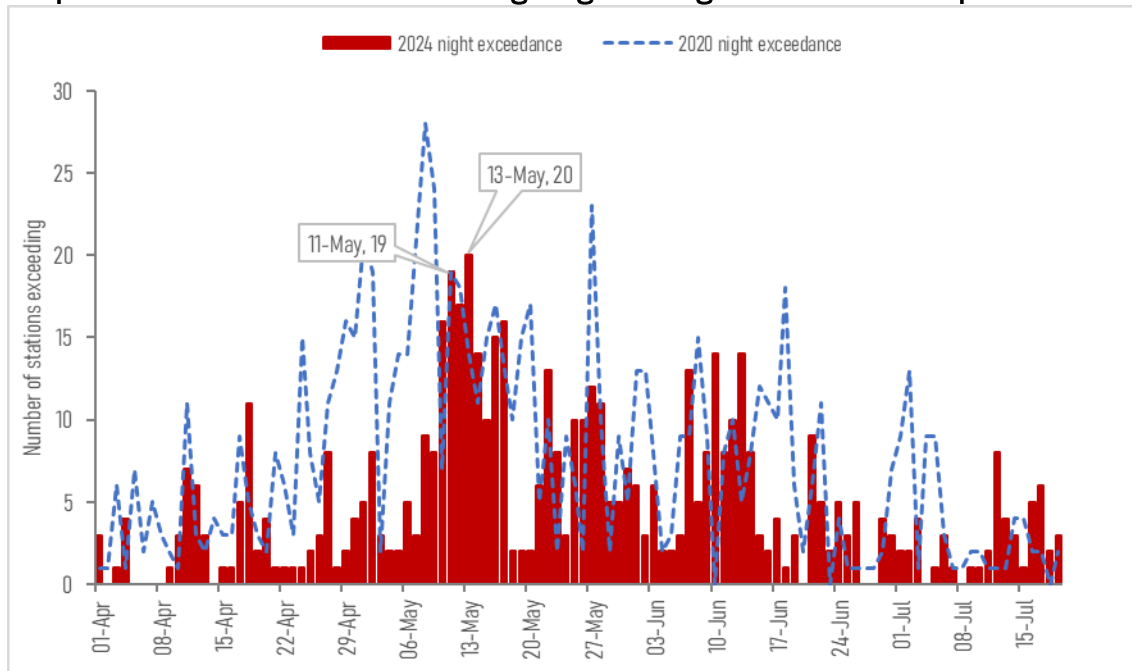
**Table 5: Locations with most night-time ground-level ozone pollution instances**

SNb	Station	Number of night-time exceedance
1	Dr KS Shooting Range, Delhi	42
2	Alipur, Delhi	34
3	DTU, Delhi	33
4	Narela, Delhi	29
5	Mundka, Delhi	27
6	Nehru Nagar, Delhi	23
7	Rohini, Delhi	22
8	Bawana, Delhi	19
9	Sonia Vihar, Delhi	19
10	Vasundhara, Ghaziabad	19

Note: Based on high hourly concentration of ground-level ozone recorded during night-time. High hourly concentration is taken as  $100 \mu\text{g}/\text{m}^3$  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 4: Variation in occurrence of high night-time ground-level ozone pollution**

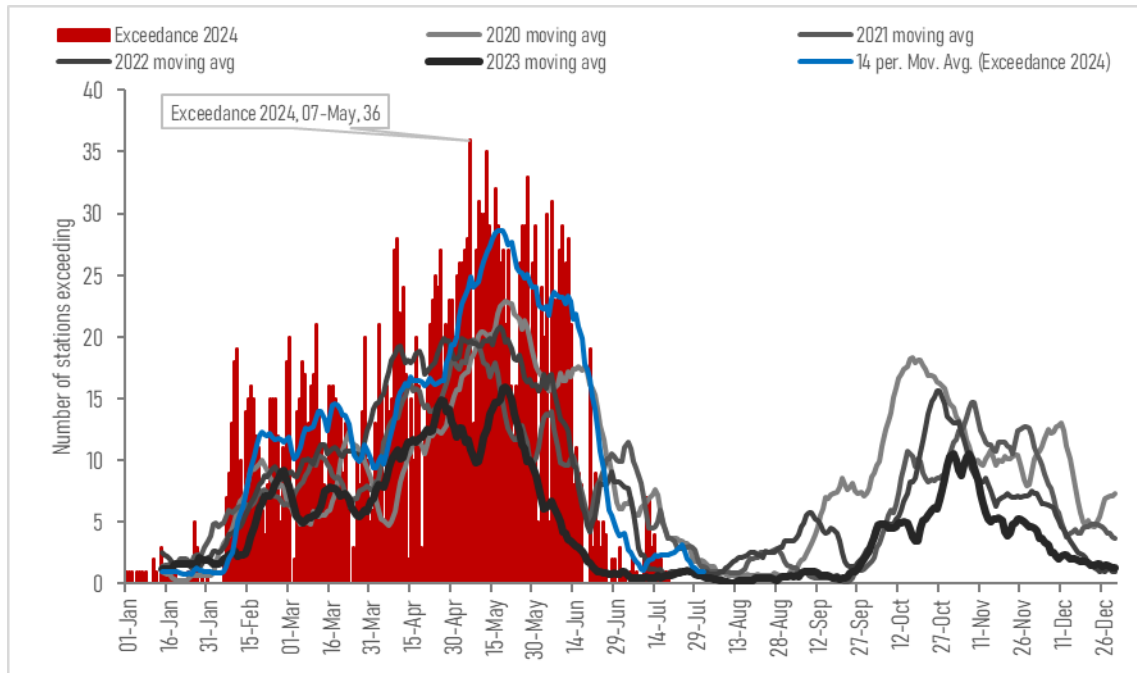


Note: Based on high hourly concentration of ground-level ozone recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida during night-time. High hourly concentration is taken as  $100 \mu\text{g}/\text{m}^3$  or more. Night-time is taken as 10PM to 2AM. Period 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 summer – especially during April-May. There is a considerable uptick in ozone pollution after monsoon – especially October-November. Foggy and cold conditions of January conventionally inhibit formation of ground-level ozone but ozone was found to be exceeding at multiple stations on 21 days this January. On the annual scale, last year exceedance were reported on 287 days, they were 334 days in 2022, 312 days in 2021, and 304 days in 2020 (See *Graph 5: Trend in ground-level ozone over years -2020-24*).

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



Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m<sup>3</sup>. 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

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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 NO<sub>x</sub> 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.