

An invisible threat: Ground-level ozone

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On the occasion of the World Environment day, the Centre for Science and Environment (CSE) issues the alert on the rising ozone pollution and a multi-pollutant crisis in Delhi and the National Capital Region during summer. If unchecked this can become a serious public health crisis in the coming years.

We have continuously alerted about the growing problem of ground-level ozone. The policy and public attention that is nearly fully drawn towards particulate pollution, has neglected mitigation and prevention of the toxic gases. Inadequate monitoring, limited data and inappropriate methods of trend analysis have weakened the understanding of this growing public health hazard. Learn from the advanced economies that after controlling particulate pollution have fallen into the grip of rising NO_x and ozone crisis. India should prevent this trap. But the standard practice of Central Pollution Control Board to average out the data of all stations to determine daily AQI cannot capture the public health risk from this short-lived and hyper-localised pollutant. This underestimates the severity of the local build up and high toxic exposures in the hotspots.

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. There should not be more than eight days in a year when the ozone standard is breached, and not on two consecutive days.

Why ozone needs special attention?

Health evidence suggest that ozone is emerging as a serious public health issue in India. 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.

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_x), volatile organic compounds (VOCs), carbon monoxide 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 not affects public health but also crop production and food security.

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 (March-May) between 2019 to 2023 May (up to May 30th). 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 $200 \mu\text{g}/\text{m}^3$ 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).

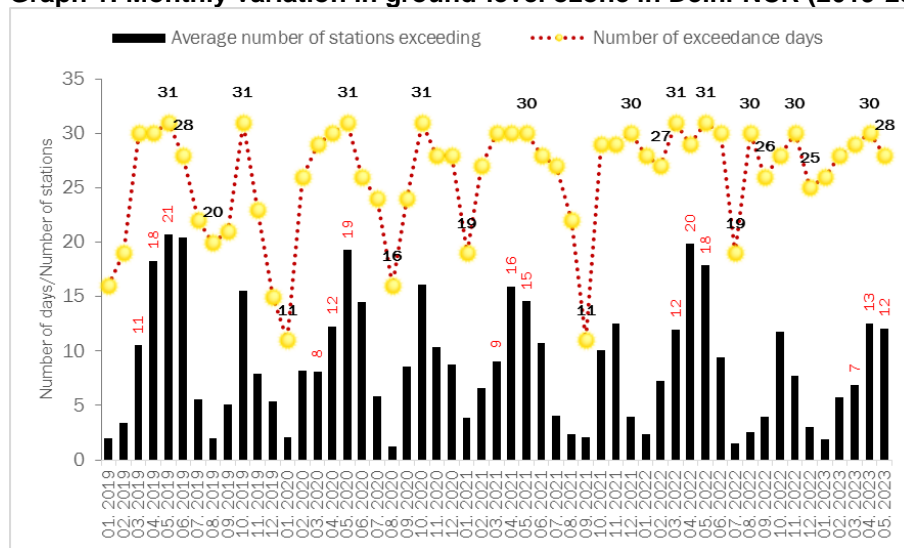
While analysing the data it has also been noted that the ozone data available on CPCB portal never exceeds $200 \mu\text{g}/\text{m}^3$, while data for the corresponding time on Delhi Pollution Control Committee may show higher levels. Therefore, due to this capping of data it is not possible to understand 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 $100 \mu\text{g}/\text{m}^3$ and one hourly standard at $180 \mu\text{g}/\text{m}^3$. Capping makes assessment of one-hourly standard challenging.



Key highlights of the analysis

Ground-level ozone exceedance is reported on nearly all days of summer: This summer ground-level ozone exceedances were reported on 87 days between 1 March and 30 May. Over the last five years it has been noted that ground-level ozone has been all season problem but it is exceptionally worse in the months of April and May (See *Graph 1: Monthly variation in ground-level ozone exceedance in Delhi-NCR*). This summer has relatively less battered by heatwaves compared to previous few summers and this is reflected in limited geographical spread of ground-level ozone exceedance. 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.

Graph 1: Monthly variation in ground-level ozone in Delhi-NCR (2019-23)

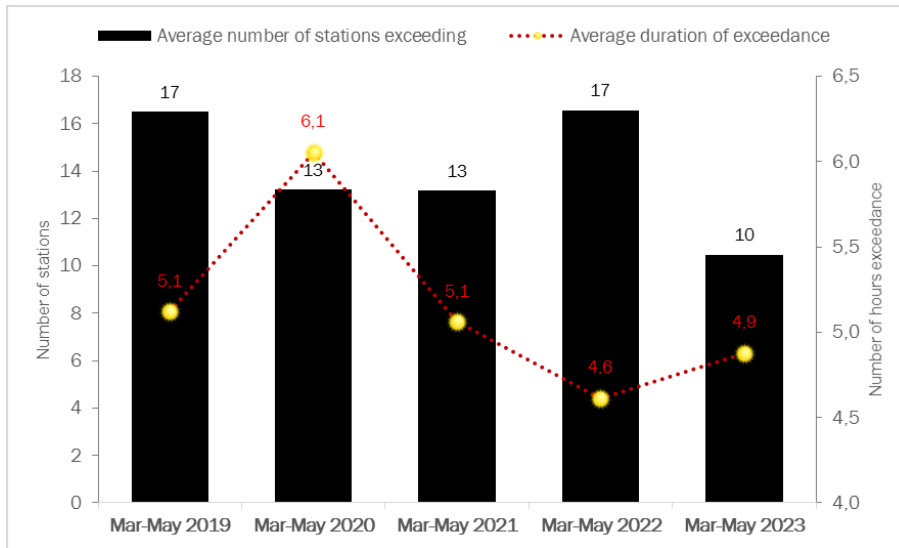


Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Summer is defined as March to May. Data till 30 May 2023. Source: CSE analysis of CPCB realtime data.

Geographical spread of ground-level ozone pollution in Delhi-NCR during March-April lowest in past 5 years, but the duration of the exceedance on the rise: Ground-level ozone usually exceeds the safety standard on all days of summer in some location in Delhi-NCR every year. The spatial spread (number of stations exceeding the standard across the core NCR) has been lower this year. On an average 10 stations have exceeded the standard daily this summer, which is 33 per cent lower from the mean of previous four summers (See *Graph 2: Variation in average duration and spatial spread of daily exceedance during summer in the core Delhi-NCR*).

Even though, the spatial spread of ground-level ozone has decreased this summer, its duration has increased. This summer, at the stations which reported exceedance the rolling 8-hr average stayed above standard for 4.9 hours on average, which is up from 4.6 hours observed the last summer.

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

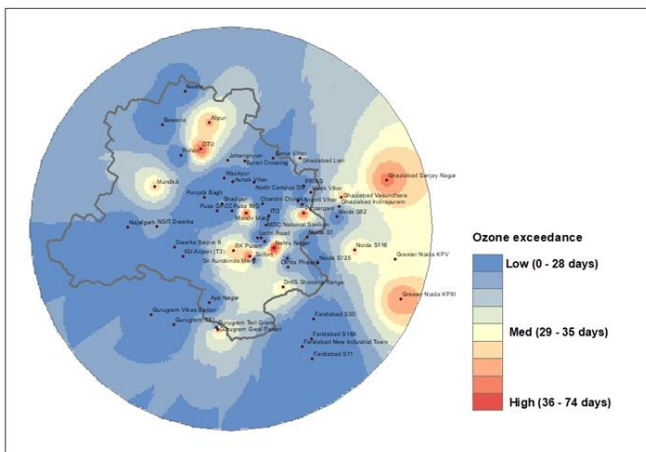


Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. $100 \mu\text{g}/\text{m}^3$. Duration of exceedance is computed as number of hours the rolling 8-hr average was exceeded at a station on a day. Summer is defined as March to May. Data till 30 May 2023. Source: CSE analysis of CPCB realtime data.

New Delhi and South Delhi neighborhoods are worst affected by ground-level ozone pollution: Nehru Nagar in south Delhi is the most chronically affected in the core Delhi-NCR. It has exceeded the standard in this location for 75 days this March-May. It is followed by Sri Aurobindo Marg, Dr KS Shooting Range and Mandir Marg 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*).

Ghaziabad, Gurugram and Greater Noida are also seriously affected by the ground-level ozone pollution. Faridabad has 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*).

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. $100 \mu\text{g}/\text{m}^3$. Summer is defined as March to May. Data till 30 May 2023. Source: CSE analysis of CPCB realtime data.

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

S.No.	Station	Number of exceedance days
1	Nehru Nagar, Delhi	75
2	Sri Aurobindo Marg, Delhi	65
3	Dr KS Shooting Range, Delhi	60
4	Mandir Marg, Delhi	60
5	Patparganj, Delhi	58
6	Sanjay Nagar, Ghaziabad	55
7	Gwal Pahari, Gurugram	53
8	Knowledge Park III, Greater Noida	52
9	Alipur, Delhi	45
10	Vasundhara, Ghaziabad	43

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 $\mu\text{g}/\text{m}^3$.

Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

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

S.No.	Station	Highest daily 8hr average
1	Punjabi Bagh, Delhi	13
2	Sector 16A, Faridabad	20
3	Sector 11, Faridabad	27
4	Ashok Vihar, Delhi	28
5	Sirifort, Delhi	28
6	Chandni Chowk, Delhi	30
7	North Campus DU, Delhi	30
8	Pusa, Delhi	32
9	New Industrial Town, Faridabad	33
10	Sector 1, Noida	35

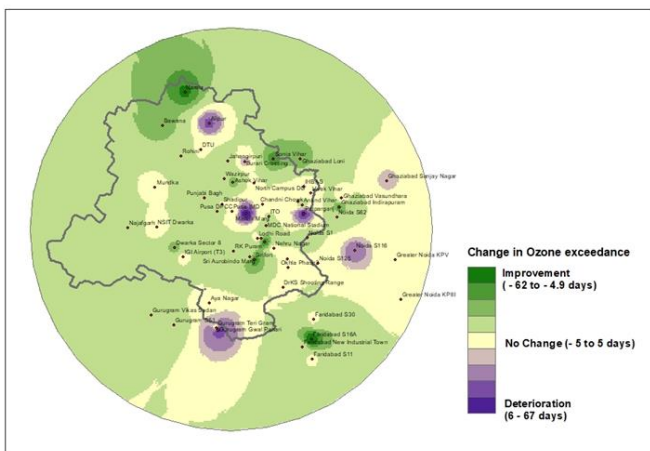
Note: No exceedance was recorded among these stations. Ranking is based on daily maximum 8-hr average. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Central Delhi and Gurugram are facing worsening trend: Mandir Marg in New Delhi registered highest increase in number of exceedance days compared to the average of last four summers. It registered a jump of 63 additional exceedance days. It was followed by Gwal Pahari in Gurugram and Patparganj in East Delhi, both registered an increase by 51 exceedance days (See *Map 2: Change in ground-level ozone exceedance in the core Delhi-NCR* & *Table 3: Locations with most increase in ground-level ozone exceedance days*).

Sector 16A in Faridabad and Sirifort in Delhi registered most reduction in exceedance days compared to average of previous four summer. Their exceedances were down by over 40 days this summer (See *Table 4: Locations with most improvement in ground-level ozone exceedance days*). JLN Stadium, Narela and Sonia Vihar in Delhi and Indrapuram and Loni in Ghaziabad were other locations that registered significant improvement.

Map 2: Change in 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/m³. Baseline is defined as average of summers of 2019, 2020, 2021 and 2022. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Table 3: Locations with most increase in ground-level ozone exceedance days

S.No.	Station	Change from baseline
1	Mandir Marg, Delhi	63
2	Gwal Pahari, Gurugram	51
3	Patparganj, Delhi	51
4	Alipur, Delhi	49
5	Sector 116, Noida	39
6	Burari Crossing, Delhi	38
7	Sanjay Nagar, Ghaziabad	33
8	Vasundhara, Ghaziabad	31
9	IHBAS, Delhi	29
10	CRRM Mathura Road, Delhi	27

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Baseline is defined as average of summers of 2019, 2020, 2021 and 2022. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Table 4: Locations with most improvement in ground-level ozone exceedance days

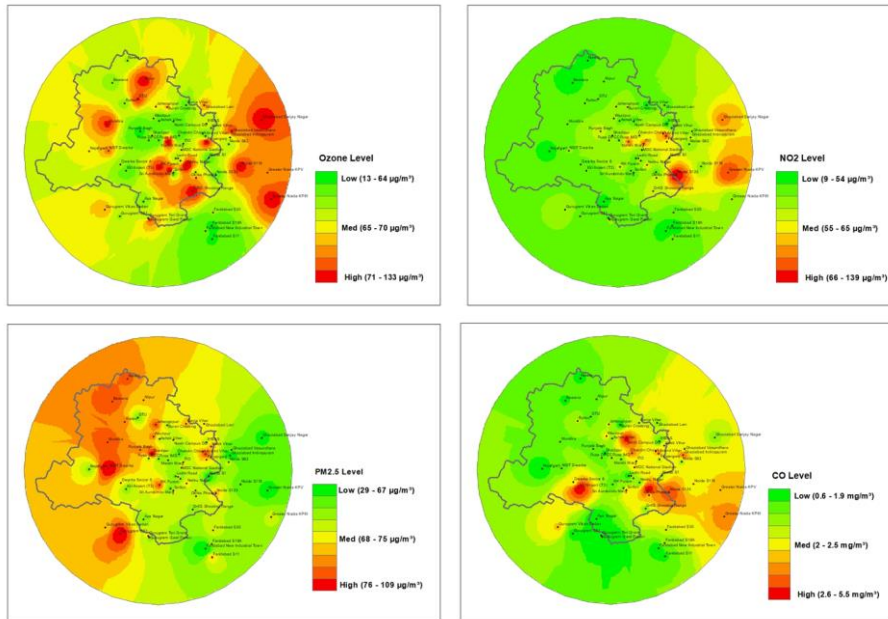
S.No.	Station	Change from baseline
1	Sector 16A, Faridabad	-48
2	Sirifort, Delhi	-44
3	JLN Stadium, Delhi	-40
4	Narela, Delhi	-26
5	Sonia Vihar, Delhi	-18
6	Indrapuram, Ghaziabad	-10
7	Loni, Ghaziabad	-7
8	Bawana, Delhi	-6
9	Ashok Vihar, Delhi	-6
10	Dwarka Sector 8, Delhi	-6

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m³. Baseline is defined as average of summers of 2019, 2020, 2021 and 2022. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Ground-level ozone hotspots are located in the areas with low levels of NO₂, CO and PM_{2.5}: The spatial distribution of ground-level ozone is inverse of the NO₂, CO and PM_{2.5} (see *Map 3: Spatial relationship among hotspots for key pollutants in the core Delhi-NCR*). Mandir Marg and Nehru Nagar in Delhi and Sanjay Nagar in Ghaziabad are exception to this phenomena as these stations report both high NO₂ and ground-level ozone (See *Table 5: Locations with the highest NO₂ pollution in the core Delhi-NCR*). Hotspots for CO and PM_{2.5} are completely distinct from the hotspots for ground-level ozone (See *Table 6: Locations with the highest CO pollution in the core Delhi-NCR* & *Table 7: Locations with the highest PM_{2.5} pollution 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 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.

Map 3: 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_{2.5} and NO₂, while daily maximum 8-hr average is used for ground-level ozone. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Table 5: Locations with the highest NO₂ pollution in the core Delhi-NCR

S.No.	Station	Summer NO ₂ average in $\mu\text{g}/\text{m}^3$
1	Sector 125, Noida	140
2	Knowledge Park V, Greater Noida	107
3	Anand Vihar, Delhi	100
4	ITO, Delhi	90
5	Mandir Marg, Delhi	86
6	Sanjay Nagar, Ghaziabad	81
7	East Arjun Nagar, Delhi	73
8	Nehru Nagar, Delhi	59
9	Patparganj, Delhi	56
10	Okhla Phase 2, Delhi	56

Note: Summer average computed as mean of monthly averages based on daily 24-hr average. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Table 6: Locations with the highest CO pollution in the core Delhi-NCR

S.No.	Station	Summer CO average in mg/m ³
1	IGI Airport T3, Delhi	5.07
2	CRRI Mathura Road, Delhi	5.06
3	North Campus DU, Delhi	4.50
4	Sector 125, Noida	4.15
5	Chandni Chowk, Delhi	3.11
6	Knowledge Park III, Greater Noida	3.06
7	Indirapuram, Ghaziabad	3.03
8	Anand Vihar, Delhi	3.01
9	Knowledge Park V, Greater Noida	2.64
10	Sirifort, Delhi	2.64

Note: Seasonal average computed as mean of monthly averages based on daily maximum 8-hr average. Summer is defined as March to May. Data till 30 May 2023.

Source: CSE analysis of CPCB realtime data.

Table 7: Locations with the highest PM2.5 pollution in the core Delhi-NCR

S.No.	Station	Summer PM2.5 average in µg/m ³
1	NSIT Dwarka	109
2	Sector 51, Gurugram	107
3	Shadipur, Delhi	105
4	Anand Vihar, Delhi	92
5	Bawana, Delhi	91
6	Mundka, Delhi	91
7	Jahangirpuri, Delhi	88
8	RK Puram, Delhi	88
9	Narela, Delhi	86
10	Wazirpur, Delhi	84

Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average. Summer is defined as March to May. Data till 30 May 2023.

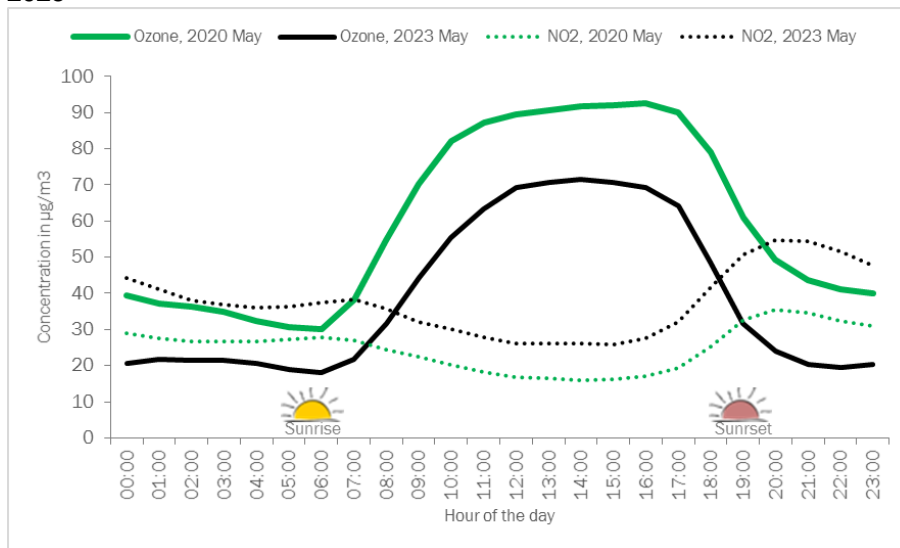
Source: CSE analysis of CPCB realtime data.

Regional hourly ozone peak level is down by 24 per cent compared to lockdown times but many stations have breached CPCB's cap this summer: Since CPCB caps the data at 200 µg/m³ 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 and the hourly peak is also on an average down by 24 per cent (See *Graph 3: Hourly cycle of ground level ozone and NO₂ in the core Delhi-NCR – May 2020 v/s May 2023*). 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 at Patparganj in Delhi hit 191 µg/m³ on 5 May 2023. This was the highest level recorded at this location ever and also the highest this summer among the stations of the core NCR. In previous summers 190 µg/m³ has been breached by stations at RK Puram, Aya Nagar, Dr KS Shooting Range, Sri Aurobindo Marg and Nehru Nagar. These stations registered peaks in 180 µg/m³ range this summer as well. Knowledge Parks in Greater Noida are peak hotspots outside Delhi (See *Table 8: Locations with the highest daily peak ground-level ozone pollution in the core Delhi-NCR*).

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 exceeding 180 µg/m³ every year. This underscores the magnitude of the pollution.

Graph 3: Hourly cycle of ground-level ozone and NO2 in the core Delhi-NCR – May 2020 v/s May 2023



Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida for month of May in 2020 and 2023. Data till 30 May 2023. Source: CSE analysis of CPCB realtime data.

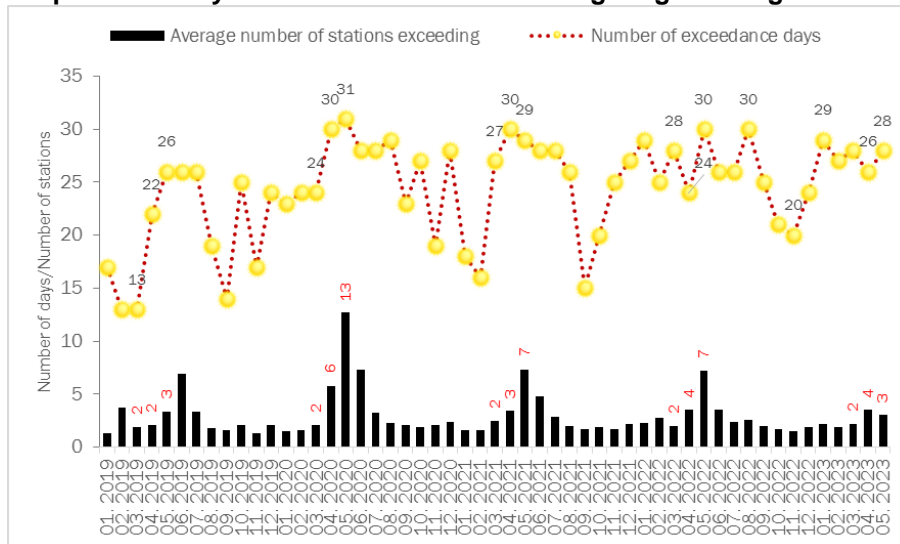
Table 8: Locations with highest daily peak ground-level ozone pollution in the core Delhi-NCR

S.No.	Station	Highest daily 8-hr average in µg/m ³
1	Patparganj, Delhi	191
2	Knowledge Park III, Greater Noida	189
3	Knowledge Park V, Greater Noida	186
4	Nehru Nagar, Delhi	185
5	Mandir Marg, Delhi	185
6	Alipur, Delhi	182
7	Mundka, Delhi	181
8	Sri Aurobindo Marg, Delhi	180
9	Dr KS Shooting Range, Delhi	179
10	Sanjay Nagar, Ghaziabad	177

Note: Based on daily maximum 8-hr average. Summer is defined as March to May. Data till 30 May 2023. 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 May night-time ozone was noted on 28 days with 3 stations on average reporting it every night (See *Graph 4: Monthly variation in occurrence of high night-time ground-level ozone pollution*). Night-time ozone has been considered when hourly concentration has exceeded the level 100 µg/m³ between 10PM and 2AM at any station. Night-time ozone is most frequently in East Arjun Nagar in East Delhi where it was reported on 42 nights this summer. Vasundhara in Ghaziabad, Knowledge Park III in Greater Noida, Gwal Pahri in Gurugram and Sector 116 in Nodia also reported most instances of night-time ground-level ozone (See *Table 9: Locations with most night-time ground-level ozone pollution instances*).

Graph 4: Monthly 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 µg/m³ or more. Night-time is taken as 10PM to 2AM. Summer is defined as March to May. Data till 30 May 2023.
Source: CSE analysis of CPCB realtime data.

Table 9: Locations with most night-time ground-level ozone pollution instances

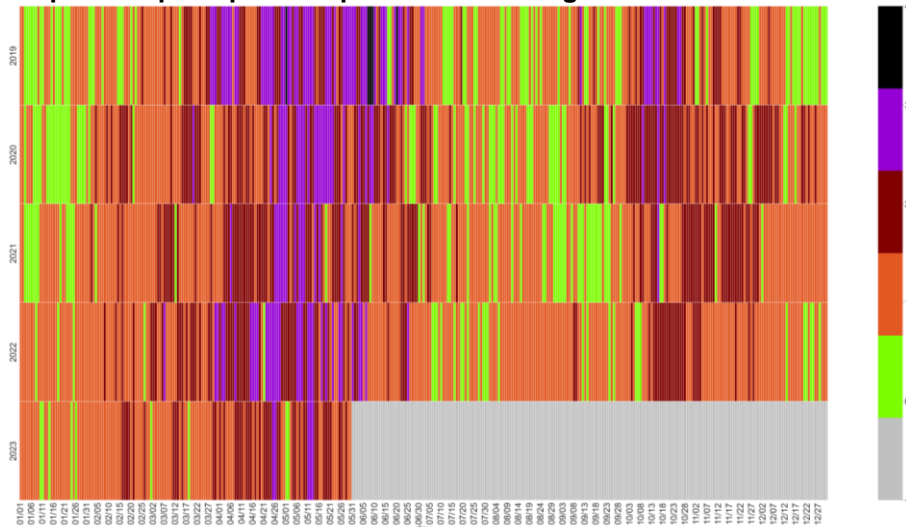
S.No.	Station	Number of night-time exceedance
1	East Arjun Nagar, Delhi	42
2	Vasundhara, Ghaziabad	15
3	Knowledge Park III, Greater Noida	15
4	Gwal Pahari, Gurugram	12
5	Sector 116, Noida	12
6	Mandir Marg, Delhi	11
7	DTU, Delhi	11
8	Alipur, Delhi	10
9	Vikas Sadan, Gurugram	9
10	Sector 125, Noida	9

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. Summer is defined as March to May. Data till 30 May 2023.
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 a few locations continue to record exceedance throughout the year. There have been only nine days this year so far that have registered no exceedance among any air quality monitoring stations of the core Delhi-NCR. Foggy and cold conditions of January conventionally inhibit formation of ground-level ozone but ozone was found to be exceeding at multiple stations on 26 days this January. On the annual scale, last year exceedance were reported on 334 days, they were only 312 days in 2021, 304 days in 2020 and 286 days in 2019 (See *Graph 5: Map of spatiotemporal variation in ground-level ozone in the core Delhi-NCR*).



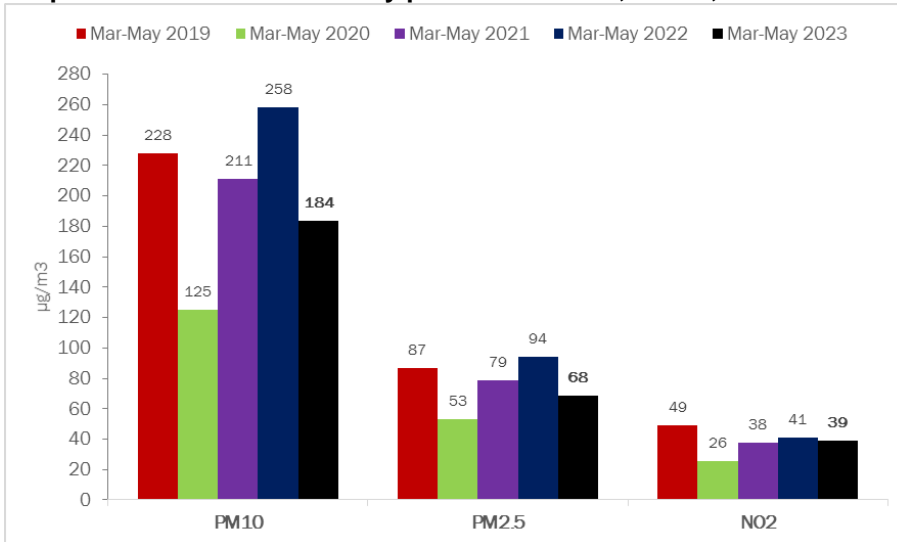
Graph 5: Map of spatiotemporal variation in ground-level ozone in the core Delhi-NCR



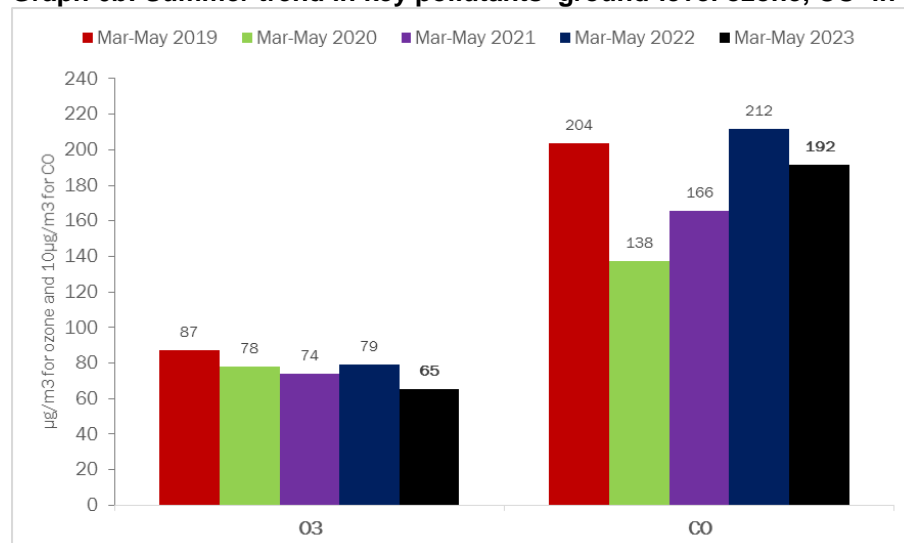
Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. $100 \mu\text{g}/\text{m}^3$. Data till 30 May 2023. Colour coding: Green = 0 exceedance; Orange = 1-10 stations exceed the standard; Maroon = 11-20 stations exceed the standard; Violet = 21-30 stations exceed the standard; Black = 31 or more stations exceed the standard. Source: CSE analysis.

Summer air is a toxic cocktail for multiple pollutants - high particulate, NO₂ and CO pollution: It is not just ground-level ozone pollution that is poisoning the summer air, significant levels of PM, CO and NO₂ are noted as well. Seasonal level of both PM₁₀ and PM_{2.5} is above their respective 24-hour standard, while CO and NO₂ levels are under the daily standard but are higher than the mean of pervious four summers. (See Graph 6a: Summer trend in key pollutants–PM₁₀, PM_{2.5}, NO₂–in the core Delhi-NCR & Graph 6b: Summer trend in key pollutants–ground-level ozone, CO–in the core Delhi-NCR).

Graph 6a: Summer trend in key pollutants–PM₁₀, PM_{2.5}, NO₂–in the core Delhi-NCR



Note: Based on mean of seasonal average recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Daily value for PM_{2.5} and NO₂ is based on 24-hr average. Summer is defined as March to May. Data till 30 May 2023. Source: CSE analysis of CPCB realtime data.

Graph 6b: Summer trend in key pollutants—ground-level ozone, CO—in the core Delhi-NCR

Note: Based on mean of seasonal average recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Daily value ground-level ozone and CO is based on maximum 8-hr average recorded on the given day. Summer is defined as March to May. Data till 30 May 2023.
Source: CSE analysis of CPCB realtime data.

Carbon-monoxide (CO) pollution is widespread and year long in Delhi-NCR: CO comes almost entirely from vehicles especially petrol vehicles and is impacted by the high intensity traffic in the region. This analysis has considered CO as in addition to being a highly toxic gas it also contributes to the ozone formation. It may be noted that India has one of the most stringent CO standards in the world. CO also has only short-term standards (1-hour and 8-hours) due to its a highly toxic nature. Therefore, it's analysis is also done in terms of exceedance days and at station level. Results point out that CO exceedance is recorded every day of the year, with its geographical spread increasing significantly during autumn and winter months (See *Graph 7: Map of spatiotemporal variation in CO in the core Delhi-NCR*).

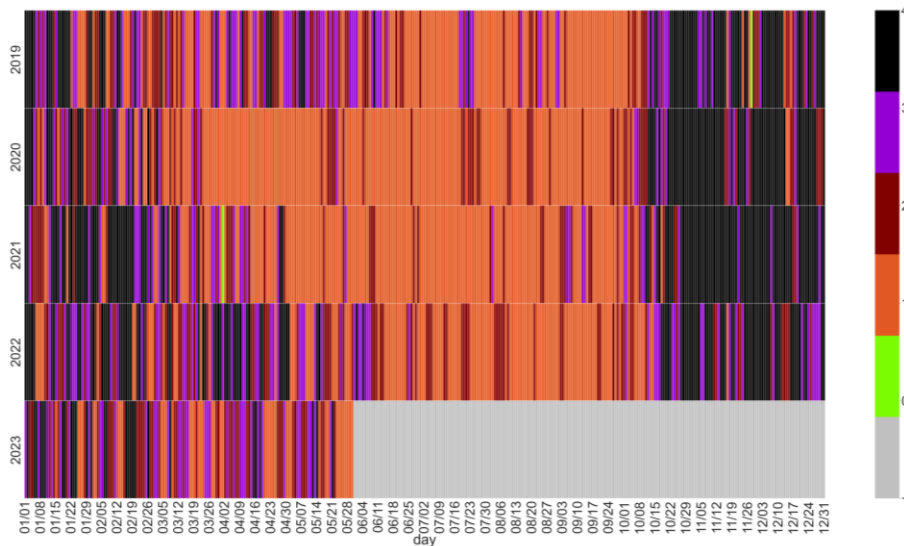
This summer Sector 125, Noida recorded 84 exceedance days which is the highest for any station in the core Delhi-NCR. It was followed by DU North Campus and IGI Airport T3 in Delhi (See *Map 4: Hotspots of CO exceedance in Delhi-NCR* & *Table 10: Locations with most CO exceedance in the core Delhi-NCR*). Ghaziabad and Gurugram are also seriously affected by the CO pollution. Najafgarh and Aya Nagar in Delhi and New Industrial Town in Faridabad are the least affected locations in the region.

Table 10: Locations with most CO exceedance in the core Delhi-NCR

S.No.	Station	Number of CO exceedance days
1	Sector 125, Noida	84
2	North Campus DU, Delhi	73
3	IGI Airport T3, Delhi	71
4	Anand Vihar, Delhi	67
5	CRRM Mathura Road, Delhi	64
6	Indrapuram, Ghaziabad	64
7	Okhla Phase 2, Delhi	57
8	Vivek Vihar, Delhi	56
9	Vikas Sadan, Gurugram	56
10	MDC National Stadium, Delhi	54

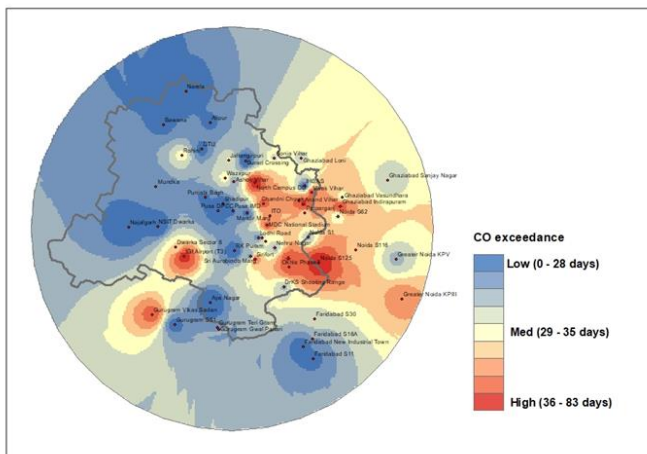
Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level CO 8-hr standard, i.e. 2 mg/m³. Summer is defined as March to May. Data till 30 May 2023.
Source: CSE analysis of CPCB realtime data.

Graph 7: Map of spatiotemporal variation in CO 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 CO 8-hr standard, i.e. 2 mg/m³. Data till 30 May 2023. Colour coding: Green = 0 exceedance; Orange = 1-10 stations exceed the standard; Maroon = 11-20 stations exceed the standard; Violet = 21-30 stations exceed the standard; Black = 31 or more stations exceed the standard. Source: CSE analysis.

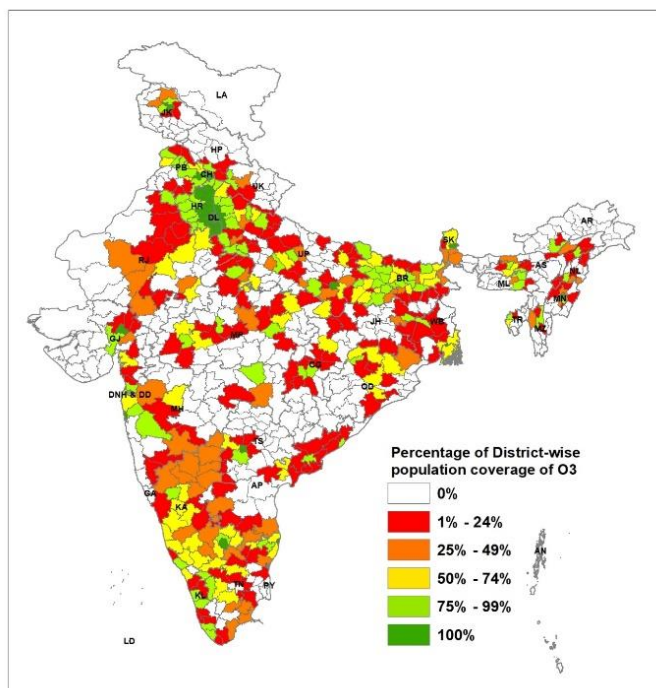
Map 4: Hotspots of CO exceedance in Delhi-NCR



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 CO 8-hr standard, i.e. 2 mg/m³. Summer is defined as March to May. Data till 30 May 2023. Source: CSE analysis of CPCB realtime data.

Nationally ozone monitoring is limited - less than half of the cities with air quality monitoring have ground-level ozone monitors: There are 476 cities that have official air quality monitoring stations either under NAMP (manual monitors) or CAAQMS (realtime monitors) or both. Of these only 200 cities have ground-level ozone monitors. CO monitors are present in 207 cities. All the ground-level ozone and CO monitors are under the CAAQMS program. 50km radius of ground-level ozone monitoring and CO monitoring only covers 75 per cent of population in 129 districts and 134 districts of India (See *Map 5: District-level population coverage by ground-level ozone monitoring network*).

Map 5: District-level population coverage by ground-level ozone monitoring network



Note: Based June 2022 district boundaries when total number of districts in India stood at 755. Population estimates are based on the 100mx100m spatial distribution of population in 2020 developed by the WorldPop research programme, based in the School of Geography and Environmental Sciences at the University of Southampton. Monitoring locations are approximation based on information available from CPCB website and publications, it is not exact geographical co-ordinate of the stations as that information is not publically available.

Source: CSE analysis

Act now

The clean air action plan and especially summer action plan cannot ignore ozone mitigation anymore. This requires very stringent action to control a range of toxic gases – that are help to form ozone – from vehicles, industry, power plants and all other combustion sources in the entire region. Stringent measures are needed to control NO_x, CO and a range of volatile organic compounds.

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

Delhi and NCR mirror the national problem. But the national assessment of the problem is inadequate mainly because of limited monitoring of ozone. This requires massive scaling up of monitoring capacity to track ozone pollution across the country.