# An invisible threat: Ground-level ozone in summer among the metros

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***This is part two of the note on ground-level ozone in Indian cities. This covers Mumbai, Kolkata, Hyderabad, Bengaluru and Chennai. Please use the link below to access the part one which covers Delhi and National Capital Region.***
***Part 1: https://www.cseindia.org/Ozone-pollution-note-Delhi-NCR.pdf***

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 emerging 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 toxic risk. This requires early action.

The summer of 2022 one the hottest summers, has witnessed unprecedented spread of ozone exceedance in Delhi-NCR more toxic. While number of stations exceeding the ozone standards have increased, this exceedance has also occurred every day during this summer. Among the six big metros Mumbai is second in order followed by Kolkata, Hyderabad, Chennai and Bangalore. Chennai and Bengaluru have longer duration of exceedance despite lower frequency compared to other metros. This has emerged from the latest air quality analysis by the Centre for Science and Environment on the occasion of the World Environment Day. This analysis is part of the air quality tracker initiative of the Urban Lab at CSE.

Health evidence is also growing stronger. The 2020 State of Global Air report states that age-standardized rates of death attributable to 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 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 ambient 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. Ground-level 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 (March-May) between 2019 to 2022 May (upto 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) have multiple stations and are covered in the study.

Given the volatile and highly localized nature of 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 a city. Breach of the standard by even one station in the city is considered exceedance by the city. 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$^3$ by CPCB, it is not possible to determine how high the concentration really goes.

This 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 highest value recorded among all city stations. 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). A simple city-wide spatial averaging has not been considered for the trend analysis though it has been assessed.

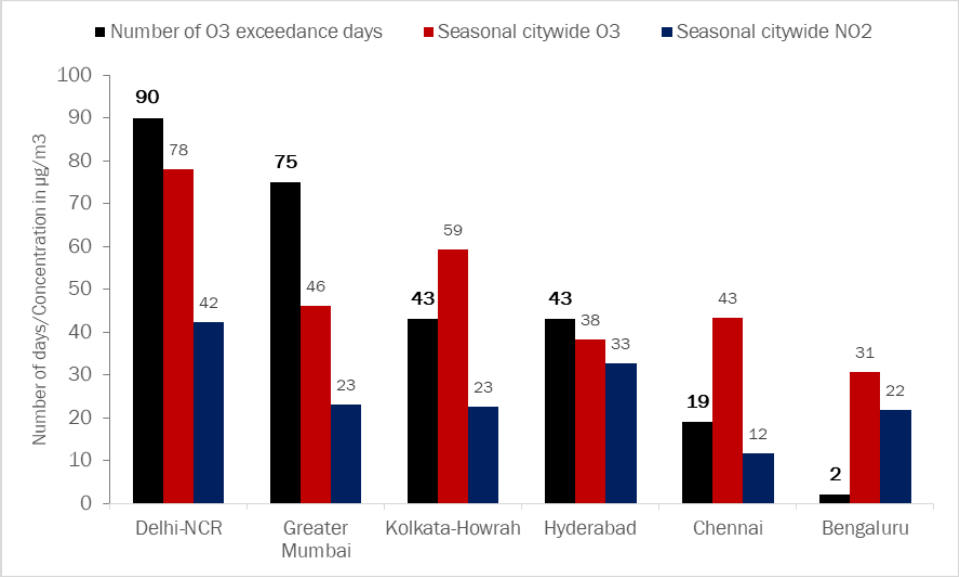
While analysing the data it has also been noted that the ozone data available on CPCB portal never exceeds 200µg/m$^3$, while data for the corresponding time on Delhi Pollution Control Committee may show higher levels. Therefore, due to this capping of data it is not possible to understand the nature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

## Key highlights of the analysis

**Delhi and Mumbai have severe ozone problem, other metros not safe either:** Delhi-NCR recorded ozone exceedance on almost all days of this summer. Mumbai with 75 days of exceedance was the second most impacted metro. Kolkata-Howrah and Hyderabad registered 43 days of exceedance each (See *Graph 1: Comparison of ground-level ozone pollution among the metro cities (March-May, 2022)*). Even though the number of exceedance days in Kolkata-Howrah have been lower than that of Mumbai but its citywide concentration is 30 per cent higher than Mumbai for this summer season. This implies that denser network of monitoring stations in Mumbai is able to catch instances of ozone exceedance better. Greater Mumbai has 26 monitoring stations while Greater Kolkata has only 10 stations.

It must also be noted that apart from Delhi all the other metros report higher instances of ozone exceedance in winter and not in summer.

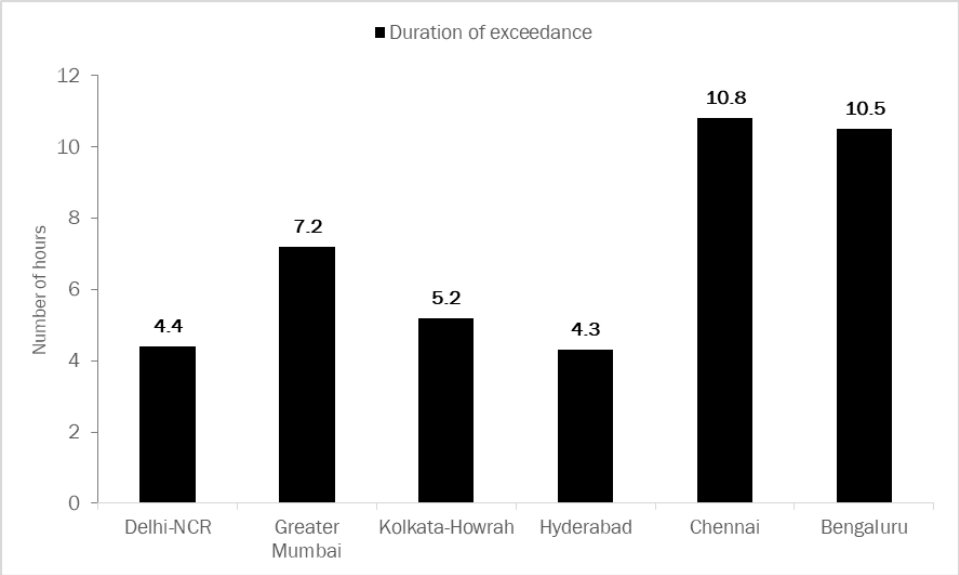
**Graph 1: Comparison of ground-level ozone pollution among the metro cities (March-May, 2022)**




Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Seasonal citywide value are determined by averaging seasonal average of all stations in the city. Seasonal average is based on daily values and for NO2 it is based on 24-hr average while daily value for ground-level ozone is based on maximum 8-hr average recorded on the given day. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Chennai and Bengaluru have longer duration of exceedance despite lower frequency compared to other metros:** The rolling 8-hr average of ground-level ozone stayed above standard for over 10 hours in Chennai and Bengaluru when exceedance occurred (See *Graph 2: Comparison of average duration of ground-level ozone exceedance among the metro cities (March-May, 2022)*). This is significantly higher than Delhi, Hyderabad and Kolkata where it lasts 4-5 hours. Mumbai reports duration of 7.2 hours.

**Graph 2: Comparison of average duration of ground-level ozone exceedance among the metro cities (Mar-May, 2022)**

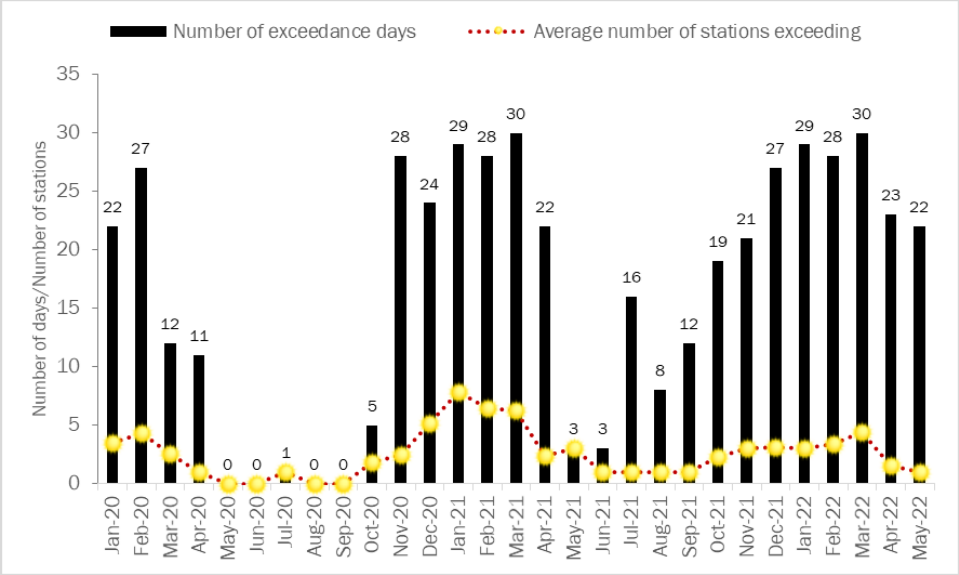



Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Duration of exceedance is computed as number of hours the rolling 8-hr average was exceeded at a station on a day. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data

## Greater Mumbai

**For Mumbai ground-level ozone is becoming a yearlong problem:** There have been 75 days this summer so far that have registered exceedance among the air quality monitoring stations of greater Mumbai. This is a 36 per cent increase from last year. Generally, ground-level ozone has been a winter problem in Mumbai with highest instances reported during December – February. This winter 84 days of exceedance were reported, last winter it was 81 days (See *Graph 3: Monthly variation in ground-level ozone in Greater Mumbai (2020-22)*).

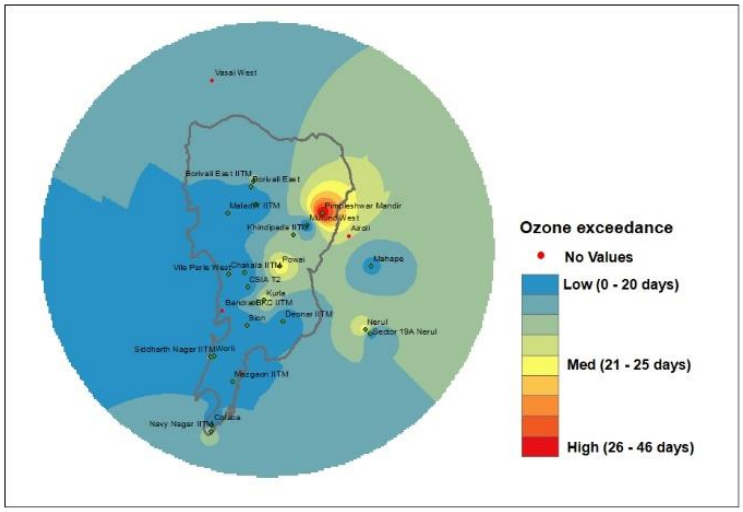
**Graph 3: Monthly variation in ground-level ozone in Greater Mumbai (2020-22)**




Note: Based on exceedances recorded at the monitoring stations at Mumbai, Navi Mumbai and Thane. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Thane, Powai and Navi Mumbai are the worst affected by ground-level ozone pollution:** Thane is the most chronically affected by ground-level ozone pollution in Greater Mumbai region. It exceeded the standard for 46 days this March-May. It is followed by Powai in Mumbai and Nerul in Navi Mumbai as the worst polluted (See *Map 1: Hotspots of ground-level ozone exceedance in Greater Mumbai (March-May 2022)*). Worli has least instances of ground-level ozone exceedances in the city.

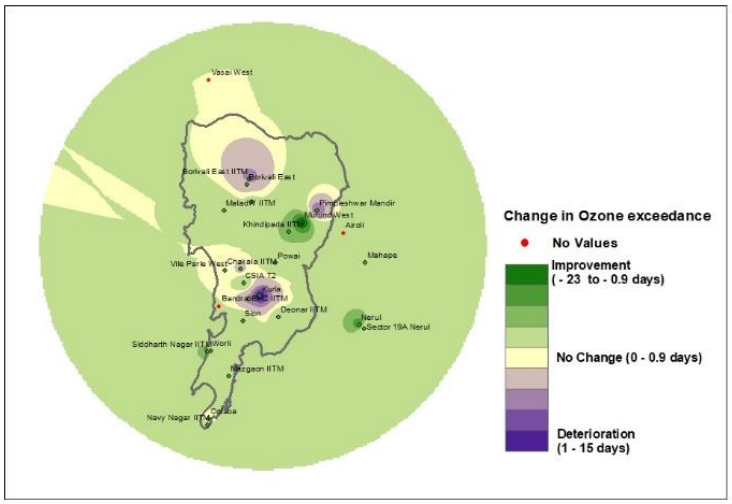
**Map 1: Hotspots of ground-level ozone exceedance in Greater Mumbai (March-May 2022)**




Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Kurla shows most increase in ground-level ozone within the city:** Kurla registered highest increase in exceedances compared to average of the last summer. It registered a jump of 15 more days of exceedance. It was followed by Borivali East with increase of 9 days of exceedence (See *Map 2: Change in hotspots of ground-level ozone exceedance in Greater Mumbai (March-May 2022 vs baseline)*). Mulund West registered most improvement.

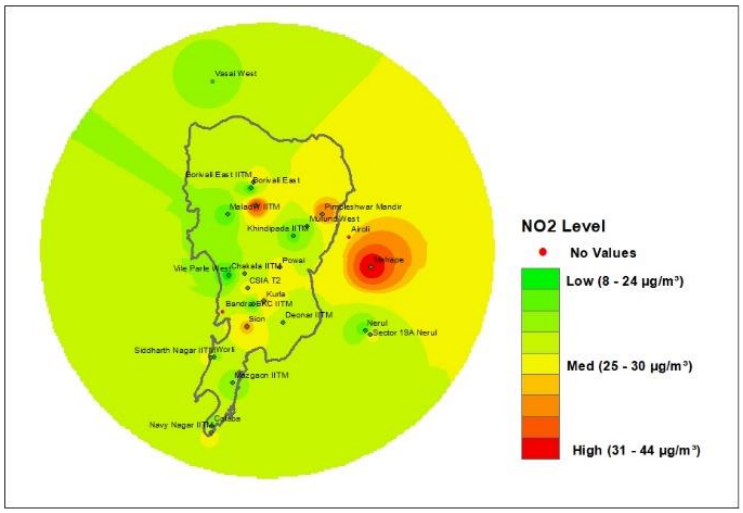
**Map 2: Change in hotspots of ground-level ozone exceedance in Greater Mumbai (March-May 2022 vs baseline)**



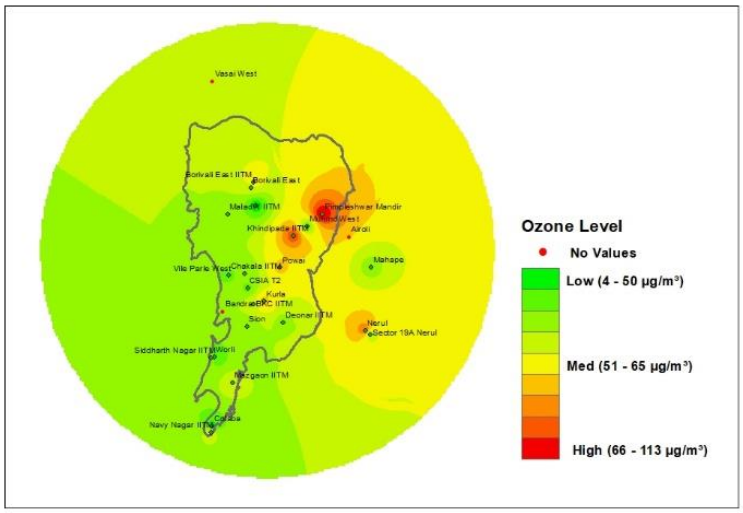

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Baseline is defined as summer of 2021. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**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 3: Spatial relationship between hotspots for NO2 and ground-level ozone in Greater Mumbai (March-May 2022*) & *Table 1: Seasonal values for NO2 and ground-level ozone at the stations in Greater Mumbai (March-May, 2022)*). Thane is an exception to this phenomena as it reports high NO2 and ground-level ozone.

**Map 3: Spatial relationship between hotspots for NO2 and ground-level ozone in Greater Mumbai (March-May 2022)**




**a) NO2 hotspots**

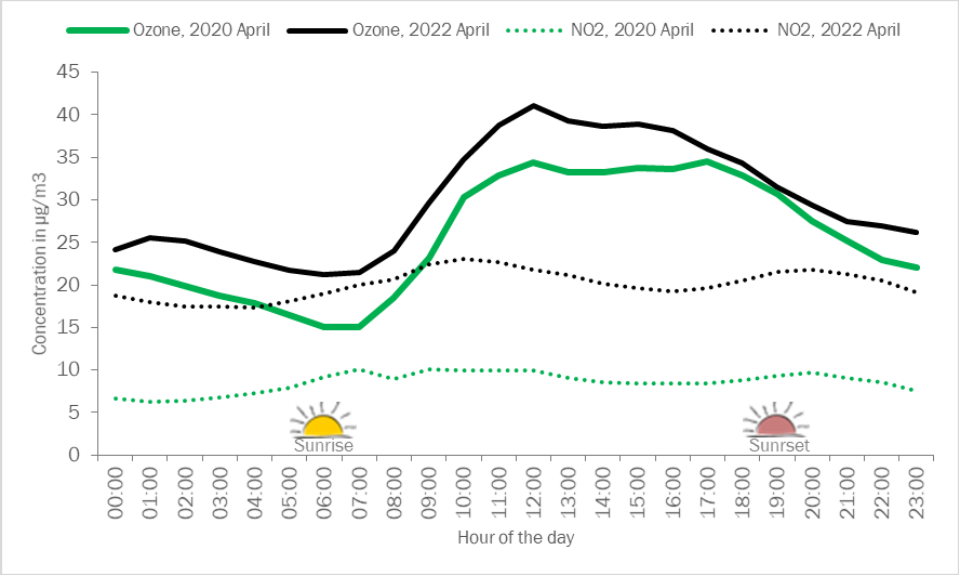



**b) Ground-level ozone**

Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for NO2, while daily maximum 8-hr average is used for ground-level ozone. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Hourly peak level are up by 19 per cent compared to lockdown times:** Compared to summer of 2020 ground-level ozone is lingering in the air post sunset and the hourly peak this year is on average 19 per cent higher (See *Graph 4: Hourly cycle of ground level ozone and NO2 in Greater Mumbai – 2020 lockdowns v/s 2022 heatwaves*). Mumbai doesn't show pronounced morning and evening NO2 build-up which is needed for neutralising ground-level ozone at sunrise and sunset.

**Graph 4: Hourly cycle of ground level ozone and NO2 in Greater Mumbai – 2020 lockdowns v/s 2022 heatwaves**




Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations at Mumbai, Navi Mumbai and Thane for month of April in 2020 AND 2022. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Table 1: Seasonal values for NO2 and ground-level ozone at the stations in Greater Mumbai (March-May, 2022)**

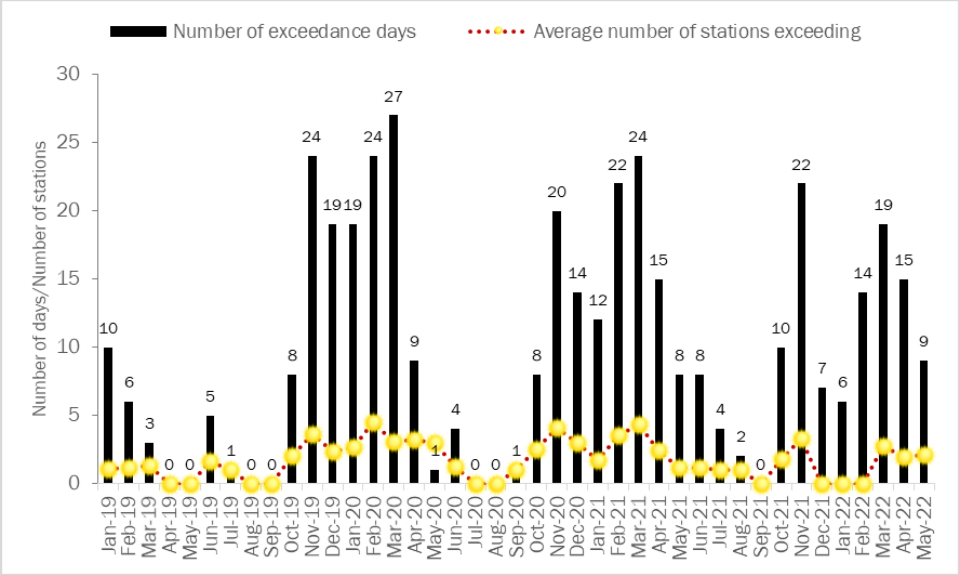
| Station | Exceedance days | Seasonal O3 level* | Seasonal NO2 level * |
|---|---|---|---|
| Pimpleshwar Mandir, Thane | 46 | 113 | 36 |
| Powai, Mumbai | 24 | 68 | 26 |
| Nerul, Navi Mumbai | 24 | 89 | 11 |
| Kurla, Mumbai | 20 | 71 | 33 |
| Navy Nagar, Mumbai | 16 | 55 | 28 |
| Borivali East 1, Mumbai | 13 | 63 | 31 |
| Khindipada, Mumbai | 11 | 98 | 14 |
| Siddharth Nagar, Mumbai | 7 | 51 | 32 |
| Bandra Kurla Complex, Mumbai | 6 | 47 | 12 |
| Mazgaon, Mumbai | 4 | 50 | 18 |
| Mahape, Navi Mumbai | 4 | 37 | 44 |
| Chakala, Mumbai | 2 | 32 | 21 |
| Borivali East 2, Mumbai | 1 | 43 | 8 |
| Sector 19A Nerul, Navi Mumbai | 1 | 40 | 28 |
| CSIA T2, , Mumbai | 1 | 25 | 28 |
| Deonar, Mumbai | 0 | 37 | 21 |
| Malad West, Mumbai | 0 | 35 | 13 |
| Mulund West, Mumbai | 0 | 32 | 17 |
| Sion, Mumbai | 0 | 31 | 33 |
| Vile Parle West, Mumbai | 0 | 26 | 10 |
| Colaba, Mumbai | 0 | 9 | 17 |
| Kandivali East, Mumbai | 0 | 8 | 41 |
| Worli, Mumbai | 0 | 4 | 13 |
| Vasai West, Mumbai | NA | NA | 19 |
| Bandra, Mumbai | NA | NA | NA |
| Airoli, Navi Mumbai | NA | NA | NA |

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Seasonal average is based on daily values and for NO2 it is based on 24-hr average while daily value for ground-level ozone is based on maximum 8-hr average recorded on the given day. * Values are in µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

# Greater Kolkata

**For Kolkata ground-level ozone is lesser this summer but it has become a yearlong problem:** There have been 43 days this summer so far that have registered exceedance among the air quality monitoring stations of greater Kolkata. This is a four days less from last summer. Generally, ground-level ozone has been a winter problem in Kolkata with highest instances reported during November – February. This winter 49 days of exceedance were reported, last winter it was 68 days, i.e. 30 per cent decline (See *Graph 5: Monthly variation in ground-level ozone in Greater Kolkata (2020-22)*).

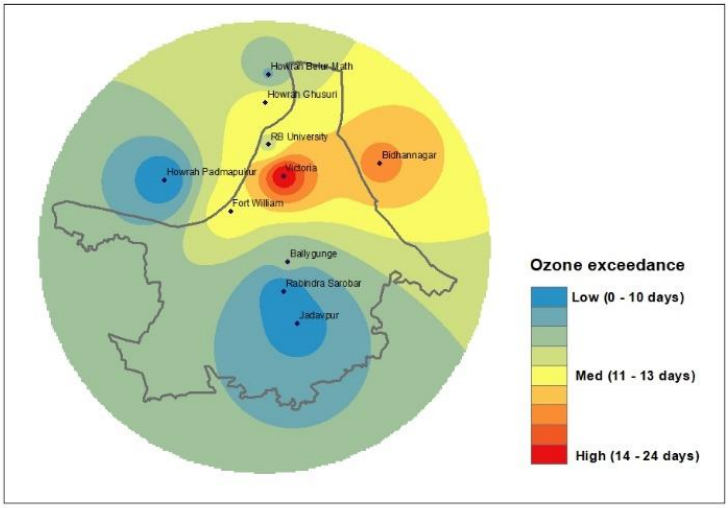
**Graph 5: Monthly variation in ground-level ozone in Greater Kolkata (2019-22)**




Note: Based on exceedances recorded at the monitoring stations at Kolkata and Howrah. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Victoria is the worst affected by ground-level ozone pollution in greater Kolkata:** Victoria is the most chronically affected by ground-level ozone pollution in Greater Kolkata region. It exceeded the standard for 24 days this March-May. It is followed by Bidhannagar and Fort William as the worst polluted (See *Map 4: Hotspots of ground-level ozone exceedance in Greater Kolkata (March-May 2022)*). Padmapukur in Howrah has least instances of ground-level ozone exceedances in the city.

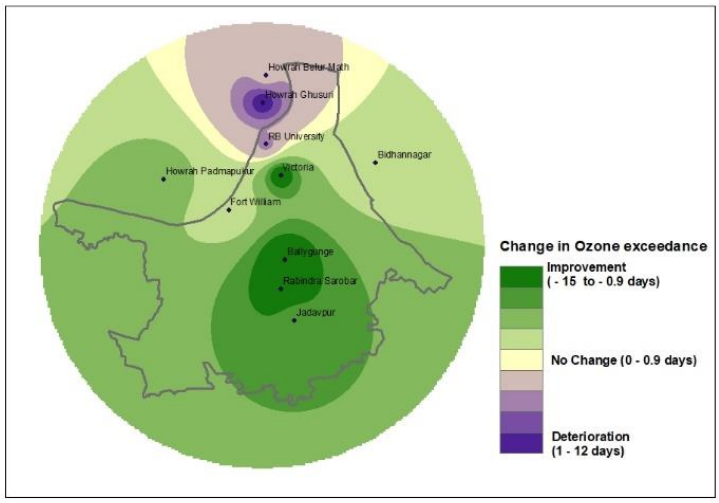
**Map 4: Hotspots of ground-level ozone exceedance in Greater Kolkata (March-May 2022)**




Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Ghusuri in Howrah shows most increase in ground-level ozone within Greater Kolkata:** Ghusuri in Howrah registered highest increase in exceedances compared to average of the last summer. It registered a jump of 12 more days of exceedance. It was followed by Rabindro Bharati University with increase of 6 days of exceedence (See *Map 5: Change in hotspots of ground-level ozone exceedance in Greater Kolkata (March-May 2022 vs baseline)*). Ballygunge registered most improvement.

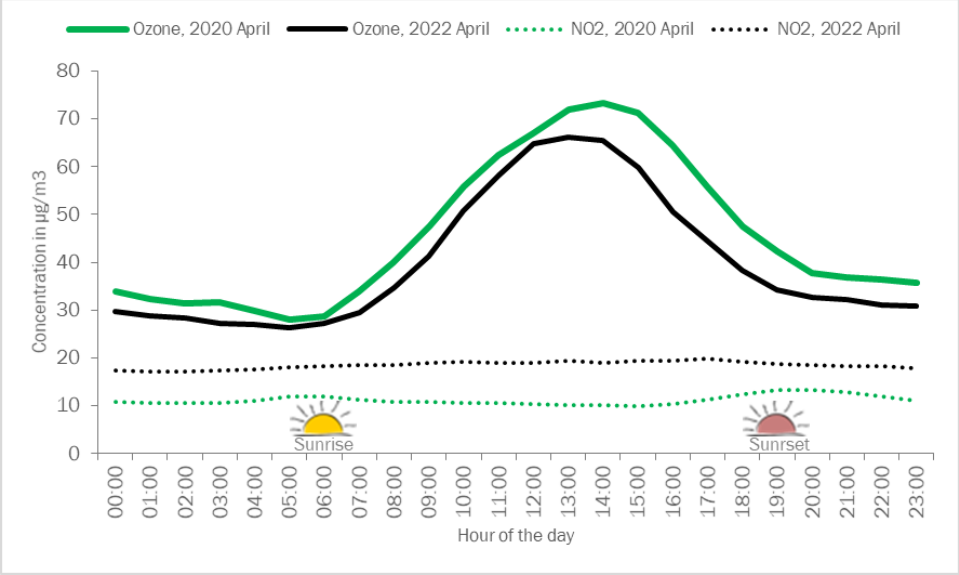
**Map 5: Change in hotspots of ground-level ozone exceedance in Greater Kolkata (March-May 2022 vs baseline)**




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 2020, and 2021. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Hourly peak level down by 10 per cent compared to lockdown times:** Compared to summer of 2020 ground-level ozone is not lingering in the air post sunset and the hourly peak this year is on average 10 per cent lower (See *Graph 6: Hourly cycle of ground level ozone and NO2 in Greater Kolkata – 2020 lockdowns v/s 2022 heatwaves*). Kolkata doesn't show pronounced morning and evening NO2 build-up which is needed for neutralising ground-level ozone at sunrise and sunset.

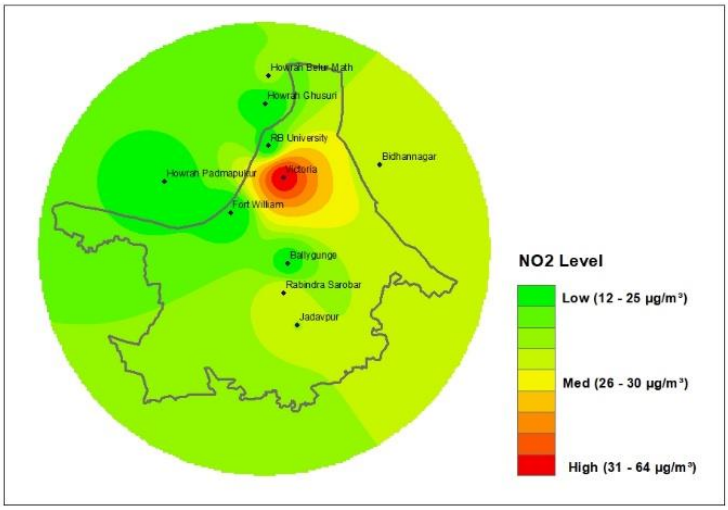
**Graph 6: Hourly cycle of ground level ozone and NO2 in Greater Kolkata – 2020 lockdowns v/s 2022 heatwaves**



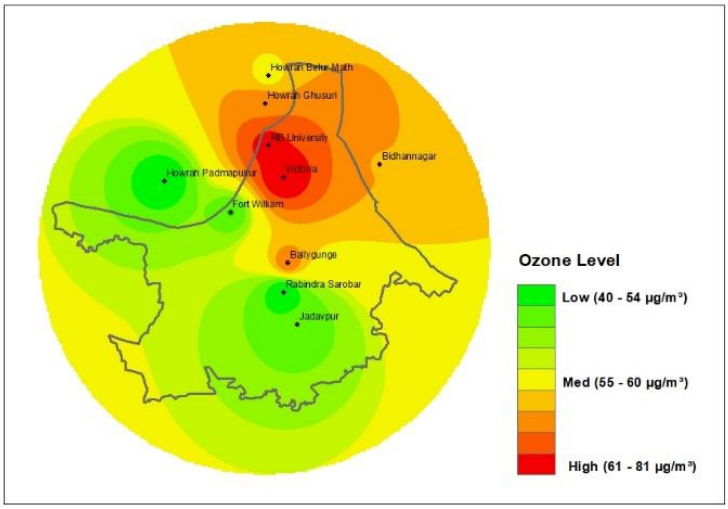

Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations at Kolkata and Howrah for month of April in 2020 AND 2022. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**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 supposed to be inverse of the NO2 but Kolkata is an exception to this (See *Map 6: Spatial relationship between hotspots for NO2 and ground-level ozone in Greater Kolkata (March-May 2022) & Table 2: Seasonal values for NO2 and ground-level ozone at the stations in Greater Kolkata (March-May, 2022)*). Victoria reports both high NO2 and ground-level ozone.

**Map 6: Spatial relationship between hotspots for NO2 and ground-level ozone in Greater Kolkata (March-May 2022)**




**a) NO2 hotspots**




**b) Ground-level ozone**

Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for NO2, while daily maximum 8-hr average is used for ground-level ozone. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Table 2: Seasonal values for NO2 and ground-level ozone at the stations in Greater Kolkata (March-May, 2022)**

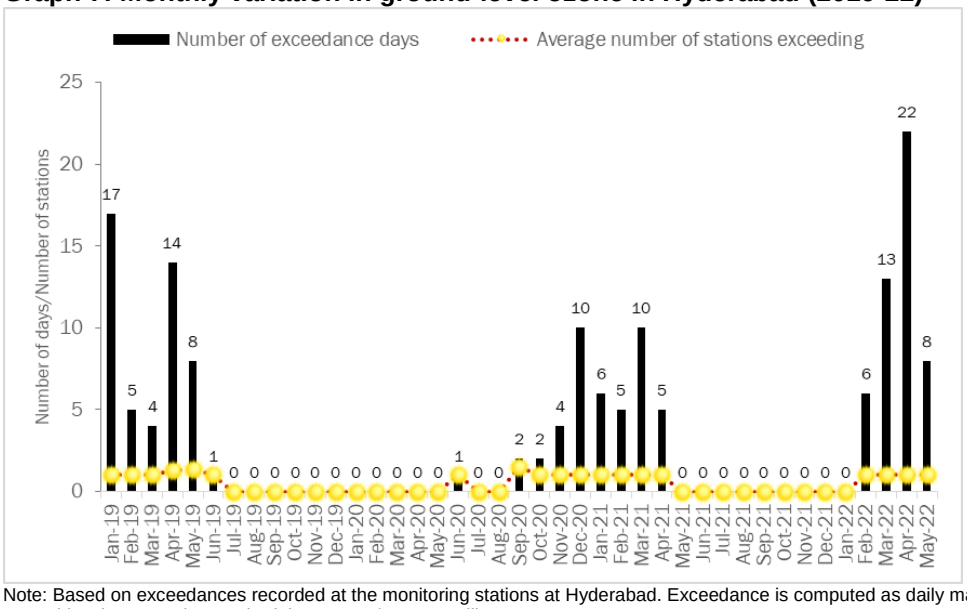
| Station | Exceedance days | Seasonal O3 level* | Seasonal NO2 level * |
|---|---|---|---|
| Victoria, Kolkata | 24 | 81 | 64 |
| Bidhannagar, Kolkata | 17 | 64 | 23 |
| Fort William, Kolkata | 13 | 47 | 12 |
| Ghusuri, Howrah | 13 | 67 | 13 |
| RB University, Kolkata | 10 | 76 | 14 |
| Ballygunge, Kolkata | 6 | 68 | 15 |
| Belur Math, Howrah | 5 | 59 | 22 |
| Jadavpur, Kolkata | 1 | 48 | 23 |
| Rabindra Sarobar, Kolkata | 0 | 41 | 26 |
| Padmapukur, Howrah | 0 | 42 | 13 |

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Seasonal average is based on daily values and for NO2 it is based on 24-hr average while daily value for ground-level ozone is based on maximum 8-hr average recorded on the given day. * Values are in µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

## Hyderabad

**For Hyderabad ground-level ozone almost tripled this summer:** There have been 43 days this summer so far that have registered exceedance among the air quality monitoring stations of Hyderabad. There were only 15 days of exceedances last summer. Generally, ground-level ozone is winter and spring seasonal winter problem in Hyderabad with highest instances reported during April (See *Graph 7: Monthly variation in ground-level ozone in Hyderabad (2019-22)*).

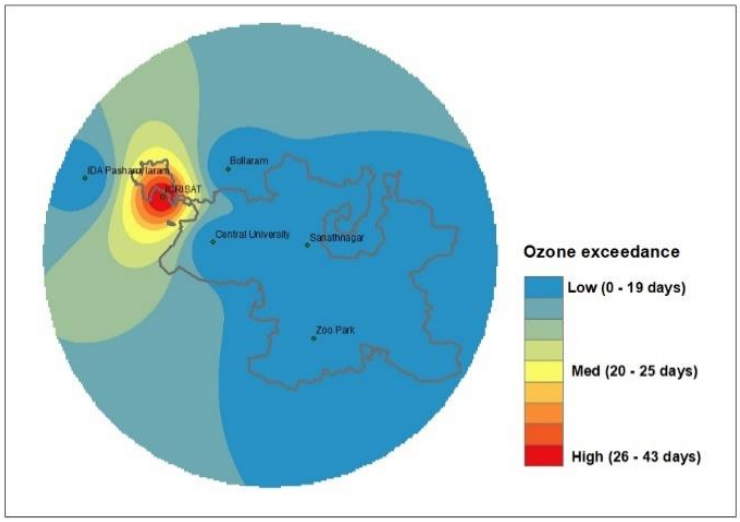
**Graph 7: Monthly variation in ground-level ozone in Hyderabad (2019-22)**




Note: Based on exceedances recorded at the monitoring stations at Hyderabad. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Patancheru is the only neighborhood with ground-level ozone pollution in Hyderabad:** Patancheru is the most chronically affected by ground-level ozone pollution in Hyderabad. It exceeded the standard for 43 days this March-May. There have been no exceedances at other stations in the city (See *Map 7: Hotspots of ground-level ozone exceedance in Hyderabad (March-May 2022)*).

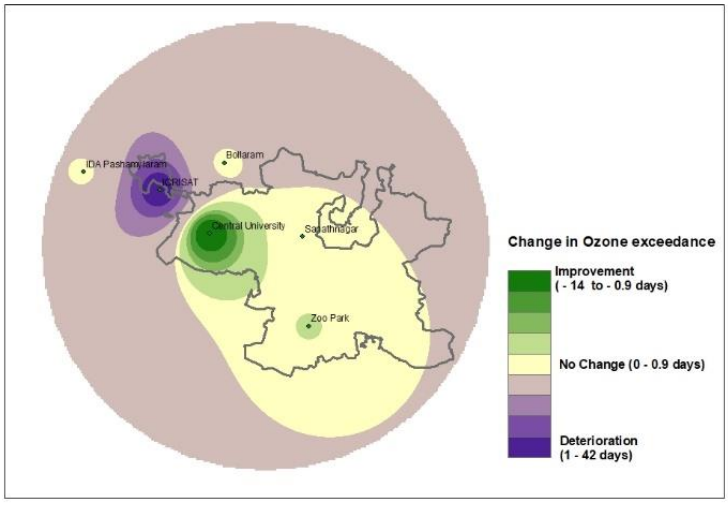
**Map 7: Hotspots of ground-level ozone exceedance in Hyderabad (March-May 2022)**




Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Patancheru shows most increase in ground-level ozone in Hyderabad:** Patancheru registered highest increase in exceedances compared to average of the last summer. It registered a jump of 42 more days of exceedance (See *Map 8: Change in hotspots of ground-level ozone exceedance in Hyderabad (March-May 2022 vs baseline)*). Central University registered most improvement.

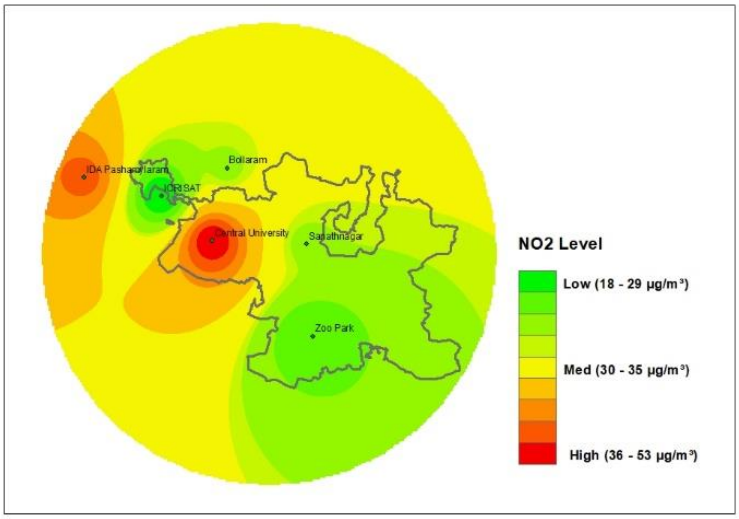
**Map 8: Change in hotspots of ground-level ozone exceedance in Hyderabad (March-May 2022 vs baseline)**



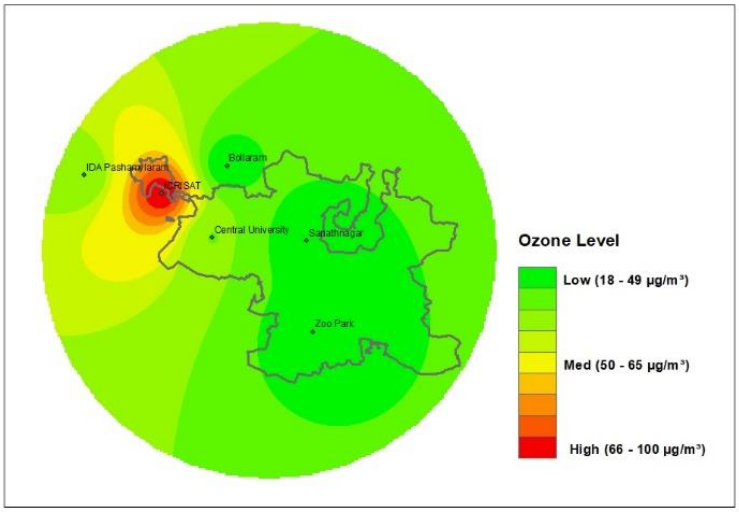

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Baseline is defined as average of 2019, 2020, and 2021. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**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 (*Map 9: Spatial relationship between hotspots for NO2 and ground-level ozone in Hyderabad (March-May 2022) & Table 3: Seasonal values for NO2 and ground-level ozone at the stations in Hyderabad (March-May, 2022)*). Patancheru has the lowest NO2 levels in the city while it is the hotspot of ground-level ozone pollution.

**Map 9: Spatial relationship between hotspots for NO2 and ground-level ozone in Hyderabad (Mar-May 2022)**




**a) NO2 hotspots**




**b) Ground-level ozone**

Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for NO2, while daily maximum 8-hr average is used for ground-level ozone. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

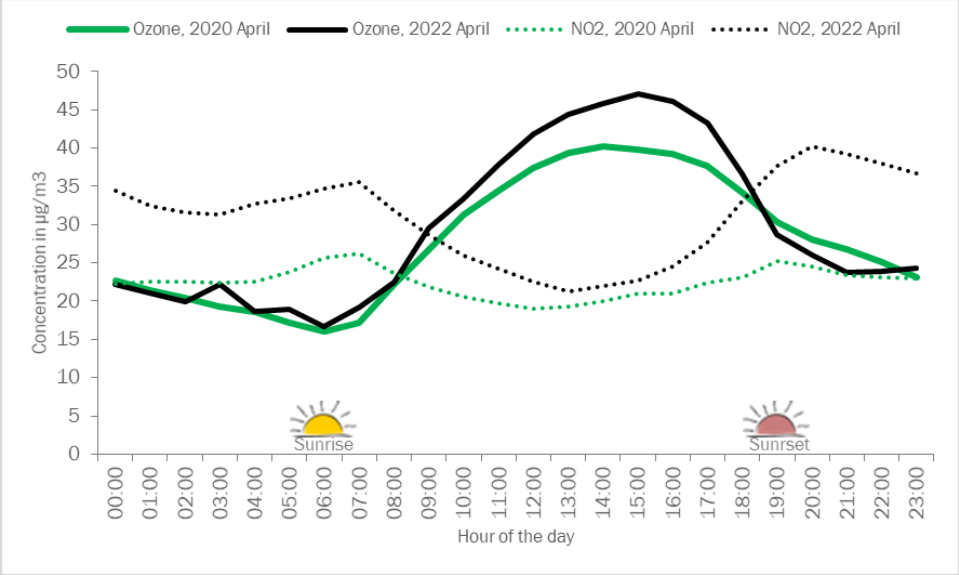
**Table 3: Seasonal values for NO2 and ground-level ozone at the stations in Hyderabad (Mar-May, 2022)**

| Station | Exceedance days | Seasonal O3 level* | Seasonal NO2 level * |
|---|---|---|---|
| ICRISAT, Hyderabad | 43 | 100 | 18 |
| IDA Pashamylaram, Hyderabad | 0 | 39 | 47 |
| Central University, Hyderabad | 0 | 36 | 53 |
| Zoo Park, Hyderabad | 0 | 20 | 22 |
| Sanathnagar, Hyderabad | 0 | 18 | 29 |
| Bollaram, Hyderabad | 0 | 18 | 29 |

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Seasonal average is based on daily values and for NO2 it is based on 24-hr average while daily value for ground-level ozone is based on maximum 8-hr average recorded on the given day. * Values are in µg/m3. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Hourly peak level are up by 18 per cent compared to lockdown times:** Compared to summer of 2020 ground-level ozone is not lingering in the air post sunset but the hourly peak this year is on average 18 per cent higher (See *Graph 8: Hourly cycle of ground level ozone and NO2 in Hyderabad – 2020 lockdowns v/s 2022 heatwaves*). 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. But presence of higher concentration of NO2 is leading to higher ozone concentration during the afternoon.

**Graph 8: Hourly cycle of ground level ozone and NO2 in Hyderabad – 2020 lockdowns v/s 2022 heatwaves**

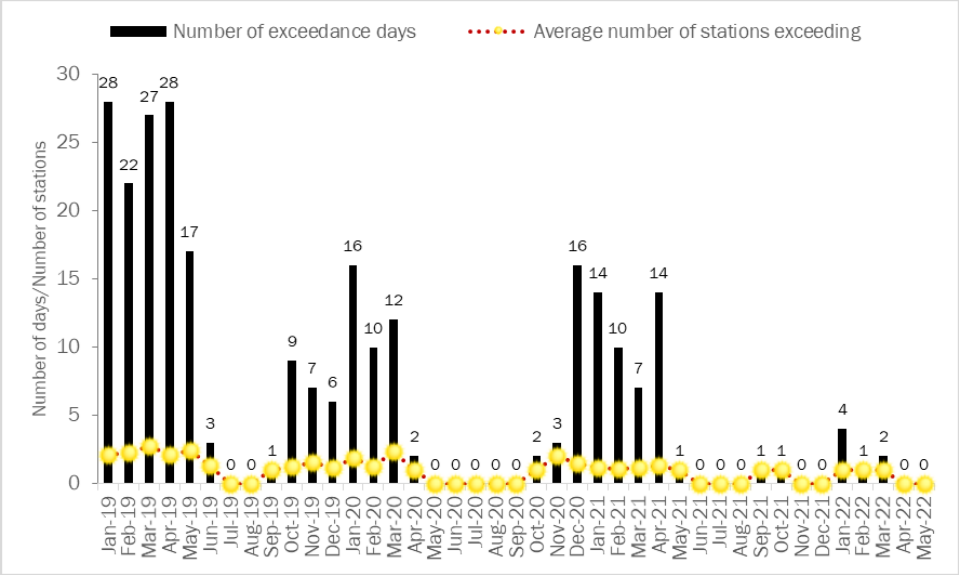



Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations at Hyderabad for month of April in 2020 AND 2022. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

# Bengaluru

**For Bengaluru ground-level ozone exceedance have almost disappeared this summer and winter:** There have been only 2 days this summer so far that have registered exceedance among the air quality monitoring stations of Bengaluru. There were only 22 days of exceedance last summer. In 2020 summer 24 exceedance days and 2019 summer 72 exceedance days were recorded. Generally, ground-level ozone is winter and spring season problem in Bengaluru with highest instances reported during January (See *Graph 9: Monthly variation in ground-level ozone in Bengaluru (2019-22)*).

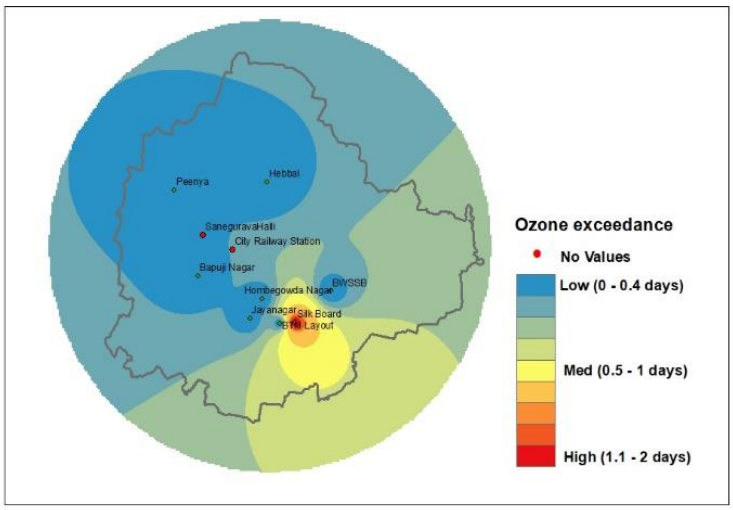
**Graph 9: Monthly variation in ground-level ozone in Bengaluru (2019-22)**




Note: Based on exceedances recorded at the monitoring stations at Bengaluru. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Silk Board is the only neighborhood with ground-level ozone pollution in Bengaluru:** Silk Board is the most chronically affected by ground-level ozone pollution in Hyderabad. It exceeded the standard for two days this March-May. There have been no exceedances at other stations in the city (See *Map 10: Hotspots of ground-level ozone exceedance in Bengaluru (March-May 2022)*).

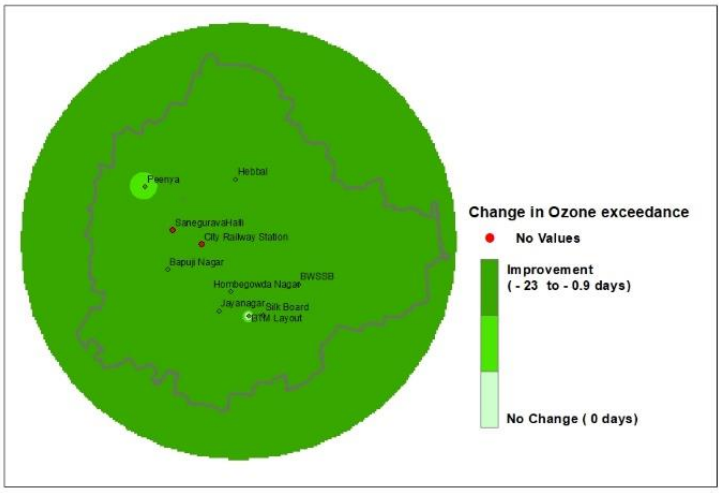
**Map 10: Hotspots of ground-level ozone exceedance in Bengaluru (March-May 2022)**




Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Hombegowda Nagar shows most improvement in ground-level ozone in Bengaluru:** No station registered an increase in exceedances compared to previous summers. Hombegowda Nagar registered most improvement. It registered a drop of 23 more days of exceedance. It was followed by Bapuji Nagar with drop of 19 days of exceedence (See *Map 11: Change in hotspots of ground-level ozone exceedance in Bengaluru (March-May 2022 vs baseline)*).

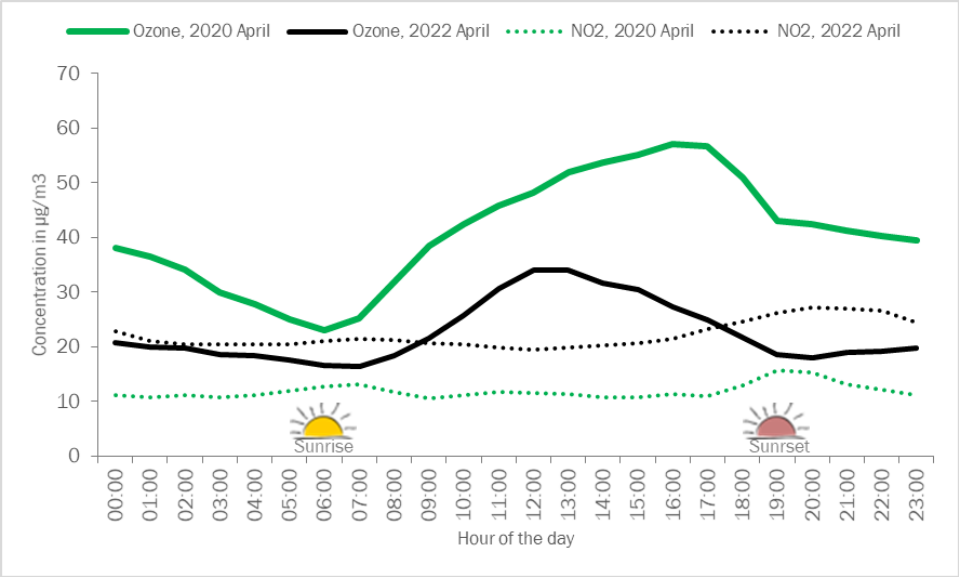
**Map 11: Change in hotspots of ground-level ozone exceedance in Bengaluru (March-May 2022 vs baseline)**




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 2019, 2020, and 2021. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Hourly peak level down by 40 per cent compared to lockdown times:** Compared to summer of 2020 ground-level ozone is not lingering in the air post sunset and the hourly peak this year is on average 40 per cent lower (See *Graph 10: Hourly cycle of ground level ozone and NO2 in Greater Bengaluru – 2020 lockdowns v/s 2022 heatwaves*).

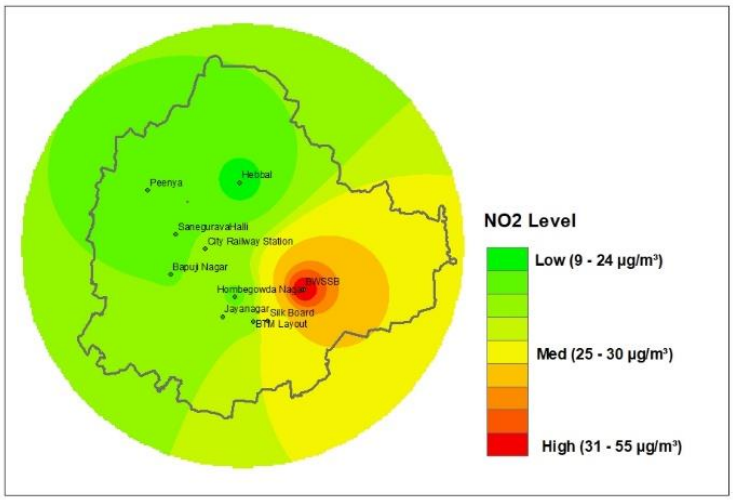
**Graph 10: Hourly cycle of ground level ozone and NO2 in Bengaluru – 2020 lockdowns v/s 2022 heatwaves**



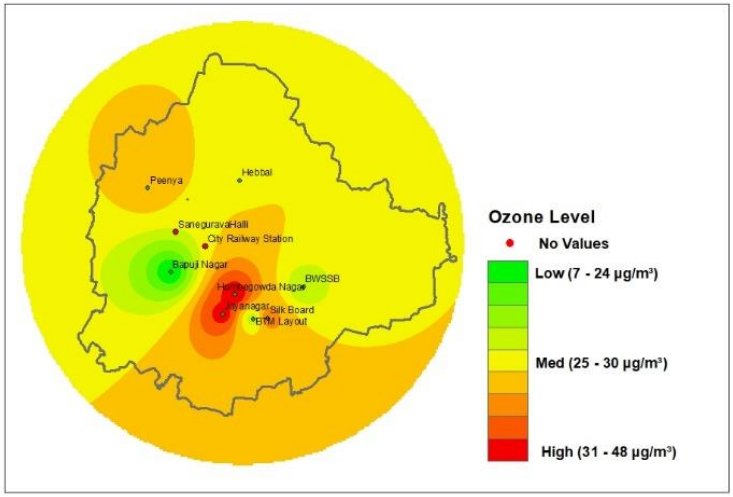

Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations at Bengaluru for month of April in 2020 AND 2022. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**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 12: Spatial relationship between hotspots for NO2 and ground-level ozone in Bengaluru (March-May 2022)* & *Table 4: Seasonal values for NO2 and ground-level ozone at the stations in Bengaluru (March-May, 2022)*). BWSSB has the highest NO2 levels in the city while it has the lowest level of ground-level ozone pollution.

**Map 12: Spatial relationship between hotspots for NO2 and ground-level ozone in Bengaluru (March-May 2022)**




**a) NO2 hotspots**




**b) Ground-level ozone**

Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for NO2, while daily maximum 8-hr average is used for ground-level ozone. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

**Table 4: Seasonal values for NO2 and ground-level ozone at the stations in Bengaluru (March-May, 2022)**

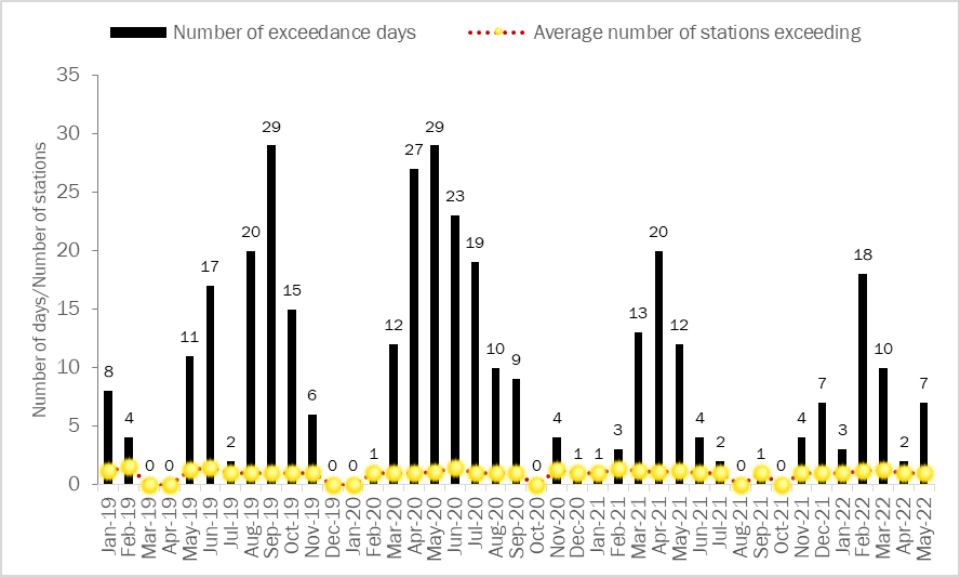
| Station | Exceedance days | Seasonal O3 level* | Seasonal NO2 level * |
|---|---|---|---|
| Silk Board, Bengaluru | 2 | 39 | 29 |
| Hombegowda Nagar, Bengaluru | 0 | 48 | 16 |
| Jayanagar, Bengaluru | 0 | 46 | 22 |
| Peenya, Bengaluru | 0 | 33 | 16 |
| Hebbal, Bengaluru | 0 | 30 | 9 |
| BTM Layout, Bengaluru | 0 | 22 | 20 |
| BWSSB, Bengaluru | 0 | 21 | 55 |
| Bapuji Nagar, Bengaluru | 0 | 7 | 18 |
| City Railway Station, Bengaluru | NA | NA | 20 |
| Sanegurava Halli, Bengaluru | NA | NA | 13 |

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Seasonal average is based on daily values and for NO2 it is based on 24-hr average while daily value for ground-level ozone is based on maximum 8-hr average recorded on the given day. * Values are in µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

## Chennai

**For Chennai ground-level ozone exceedance have declined by almost 60 per cent this summer:** There have been only 19 days this summer so far that have registered exceedance among the air quality monitoring stations of Chennai. There were 45 days of exceedance last summer. In 2020 summer 68 exceedance days and 2019 summer 28 exceedance days were recorded. Generally, ground-level ozone is summer season problem in Chennai with highest instances reported during April-May (See *Graph 11: Monthly variation in ground-level ozone in Chennai (2019-22)*). There is negligible instances of exceedance during winter in Chennai, which might be due to the fact it is the rainy season for the region.

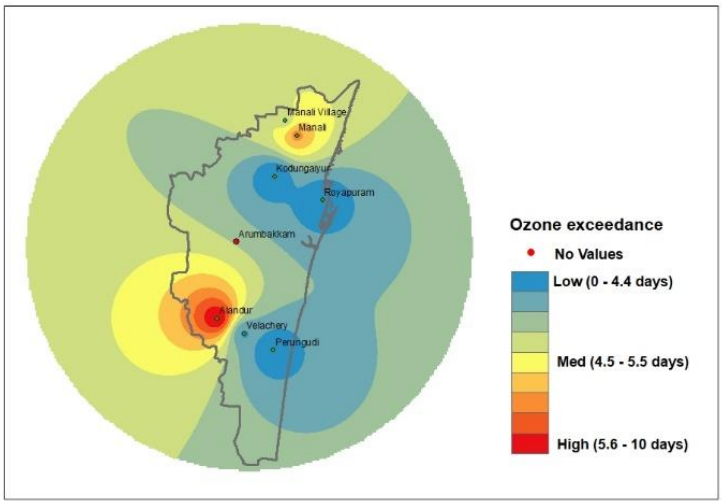
**Graph 11: Monthly variation in ground-level ozone in Chennai (2019-22)**




Note: Based on exceedances recorded at the monitoring stations at Chennai. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Alandur and Manali are the worst affected by ground-level ozone pollution in greater Kolkata:** Alandur is the most chronically affected by ground-level ozone pollution in Chennai. It exceeded the standard for 10 days this March-May. It is followed by Manali and Manali village as the worst polluted (See *Map 13: Hotspots of ground-level ozone exceedance in Chennai (March-May 2022)*). Royapuram has least instances of ground-level ozone exceedances in the city.

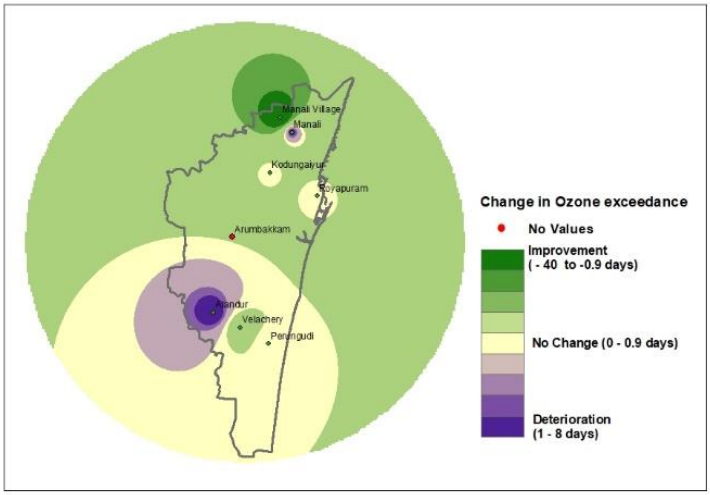
**Map 13: Hotspots of ground-level ozone exceedance in Chennai (March-May 2022)**




Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Alandur shows most increase in ground-level ozone in Hyderabad:** Alandur registered highest increase in exceedances compared to average of the last summer. It registered a jump of 8 more days of exceedance (See *Map 14: Change in hotspots of ground-level ozone exceedance in Chennai (March-May 2022 vs baseline)*). Manali registered most improvement.

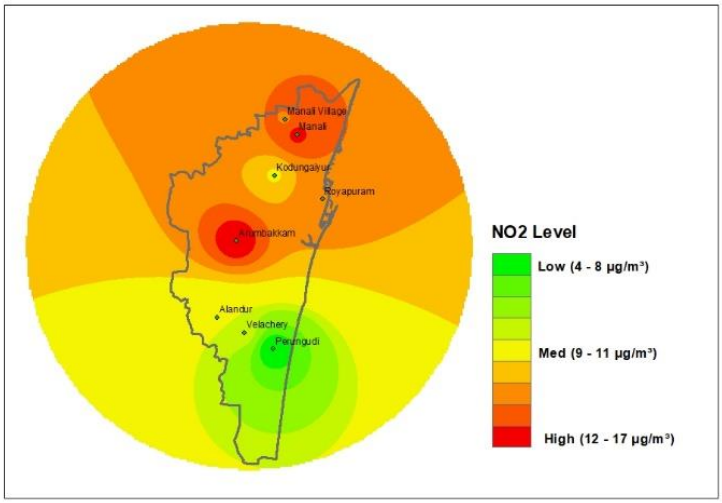
**Map 14: Change in hotspots of ground-level ozone exceedance in Chennai (March-May 2022 vs baseline)**



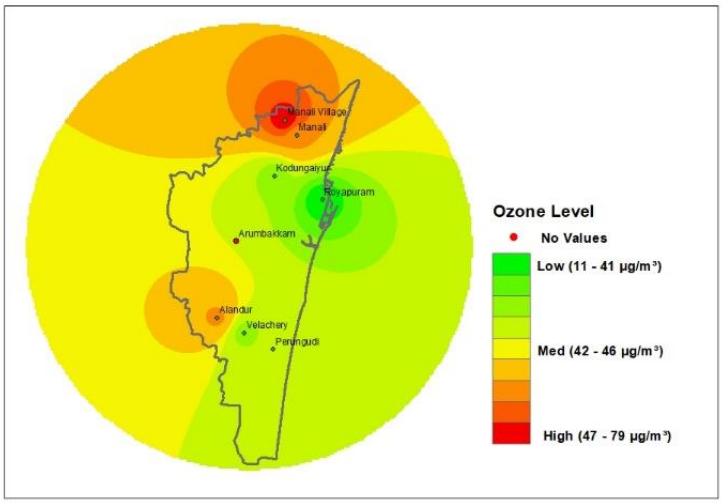

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Baseline is defined as average of 2019, 2020, and 2021. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**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 supposed to be inverse of the NO2 but Chennai is an exception to this (See *Map 15: Spatial relationship between hotspots for NO2 and ground-level ozone in Chennai (March-May 2022) & Table 5: Seasonal values for NO2 and ground-level ozone at the stations in Chennai (March-May, 2022)*). Manali reports both high NO2 and ground-level ozone.

**Map 15: Spatial relationship between hotspots for NO2 and ground-level ozone in Chennai (March-May 2022)**




**a) NO2 hotspots**




**b) Ground-level ozone**

Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for NO2, while daily maximum 8-hr average is used for ground-level ozone. Data till 30 May 2022. Source: CSE analysis of CPCB realtime data.

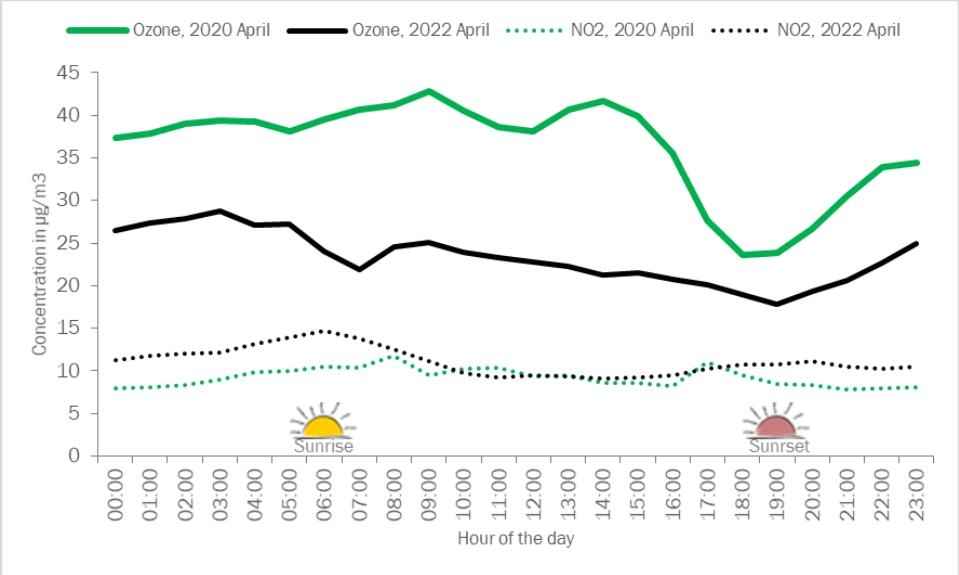
**Table 5: Seasonal values for NO2 and ground-level ozone at the stations in Chennai (March-May, 2022)**

| Station | Exceedance days | Seasonal O3 level* | Seasonal NO2 level * |
|---|---|---|---|
| Alandur, Chennai | 10 | 59 | 9 |
| Manali, Chennai | 7 | 59 | 16 |
| Manali Village, Chennai | 4 | 79 | 14 |
| Velachery, Chennai | 1 | 30 | 9 |
| Perungudi, Chennai | 0 | 36 | 4 |
| Kodungaiyur, Chennai | 0 | 29 | 11 |
| Royapuram, Chennai | 0 | 11 | 14 |
| Arumbakkam, Chennai | NA | NA | 17 |

Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Seasonal average is based on daily values and for NO2 it is based on 24-hr average while daily value for ground-level ozone is based on maximum 8-hr average recorded on the given day. * Values are in µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

**Hourly peak level down by 31 per cent compared to lockdown times:** Compared to summer of 2020 ground-level ozone is not lingering in the air post sunset and the hourly peak this year is on average 40 per cent lower (See *Graph 12: Hourly cycle of ground level ozone and NO2 in Greater Chennai – 2020 lockdowns v/s 2022 heatwaves*). Chennai doesn't show the typical ozone cycle. City seems to be having consistent concentration of ground-level ozone through day and night, which is strange and needs further investigation.

**Graph 12: Hourly cycle of ground level ozone and NO2 in Chennai – 2020 lockdowns v/s 2022 heatwaves**




Note: 24-hr profile is based on mean hourly concentration of ground-level ozone and NO2 recorded at the monitoring stations at Chennai for month of April in 2020 AND 2022. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.