
CSE
WEBINARS
AN INVISIBLE THREAT
Ground-level ozone pollution in summers
Dates: Friday, June 3, 2022
Time: 4-5 PM India Time
Platform: Zoom
To register visit www.cseindia.org

Ozone Alert!

Understanding the growing spread and frequency of ground-level ozone pollution among Indian cities

Avikal Somvanshi & Sharanjeet Kaur

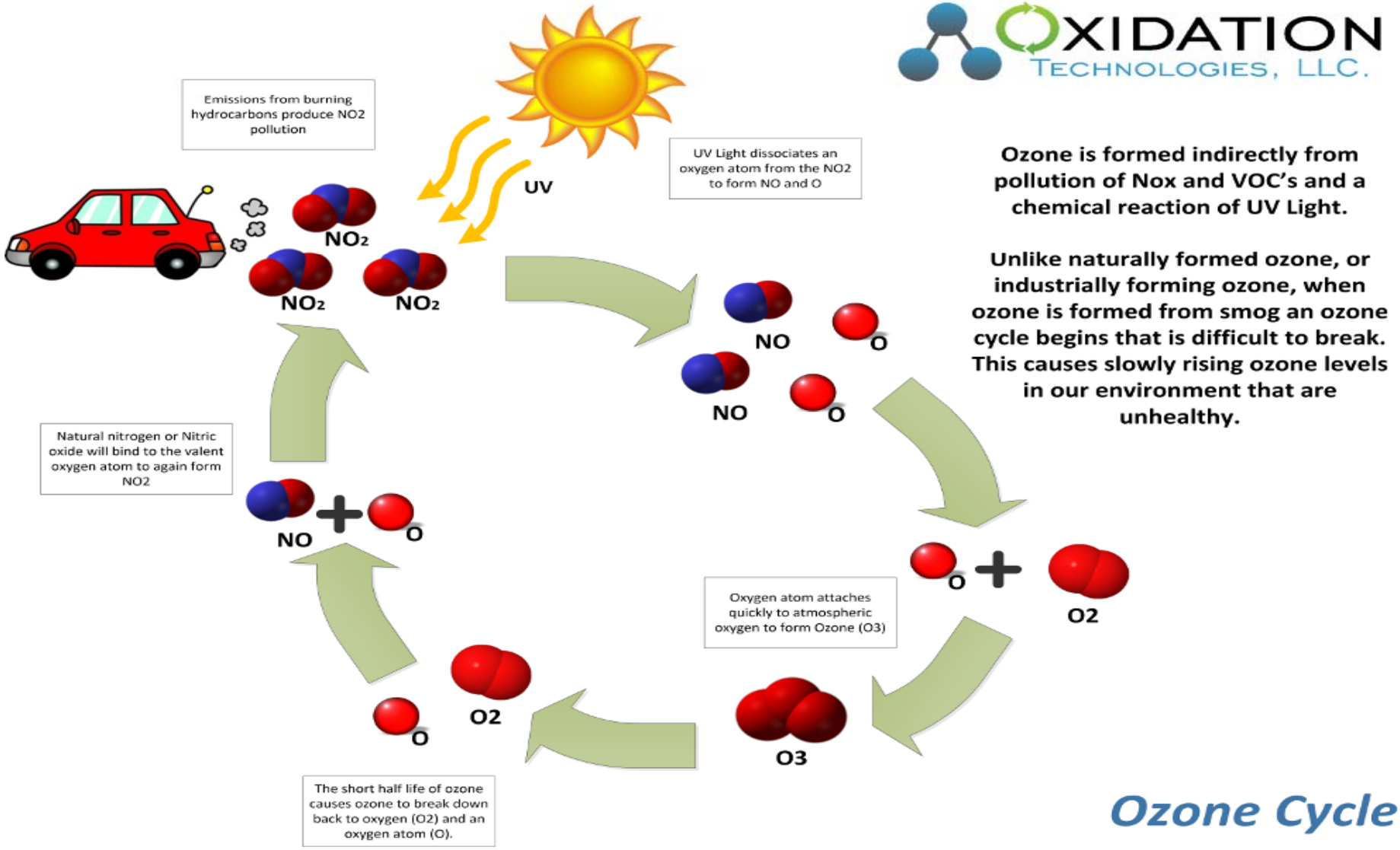
Urban Lab, Centre for Science and Environment

June 3, 2022

Ozone layer v/s Ground-level ozone

Source: https://www.climatecentral.org/gallery/graphics/explainer-how-ground-level-ozone-is-formed

Science of ground-level ozone



OXIDATION TECHNOLOGIES, LLC.

Ozone is formed indirectly from pollution of Nox and VOC's and a chemical reaction of UV Light.

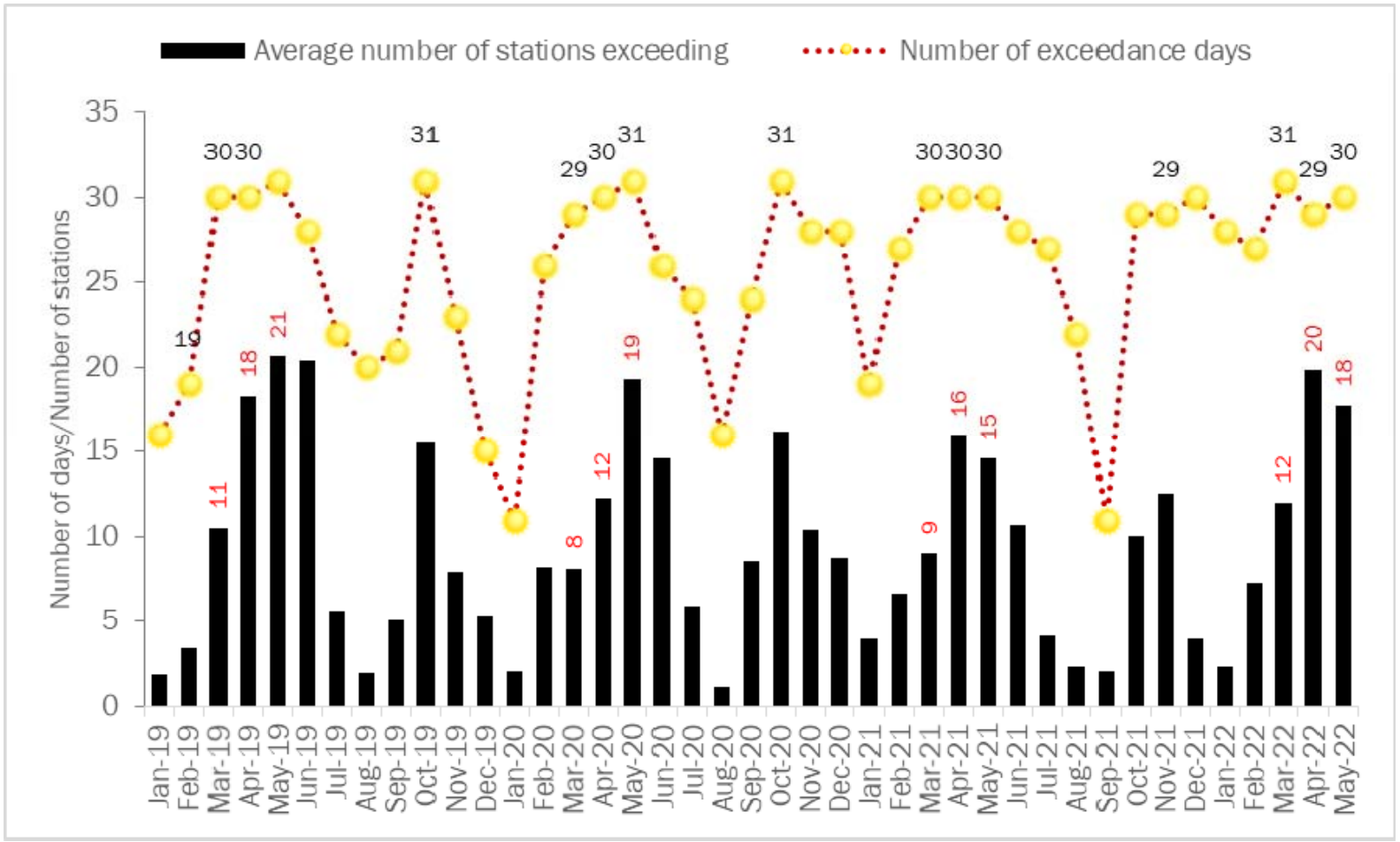
Unlike naturally formed ozone, or industrially forming ozone, when ozone is formed from smog an ozone cycle begins that is difficult to break. This causes slowly rising ozone levels in our environment that are unhealthy.

Ozone Cycle

Source: https://www.oxidationtech.com/ozone/ozone-production.html

Heatwaves advanced the geographical spread of ground-level ozone

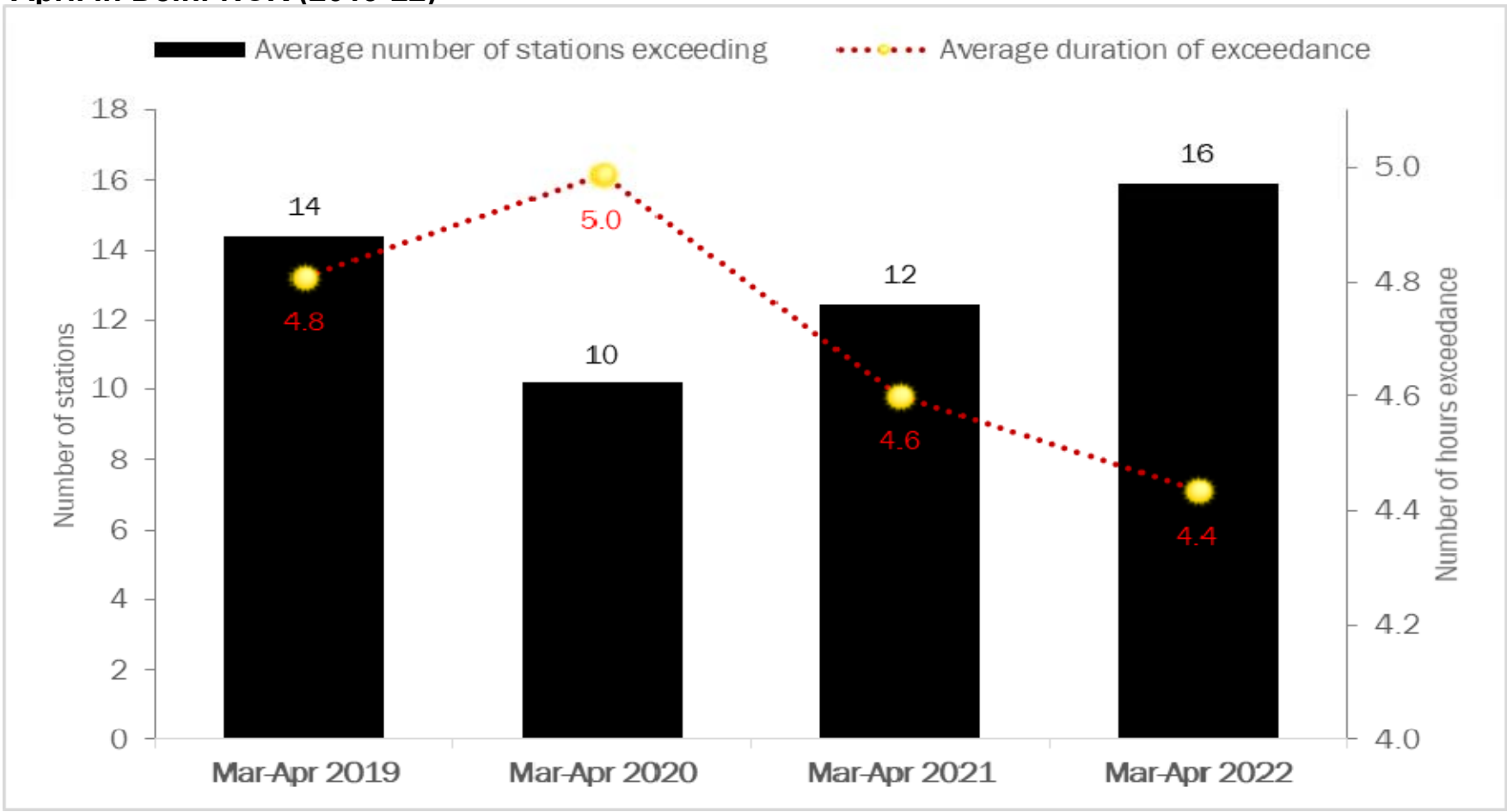
Graph 1: Monthly variation in ground-level ozone in Delhi-NCR (2019-22)



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. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

Geographical spread of ground-level ozone pollution in Delhi-NCR during March-April highest in past 4 years

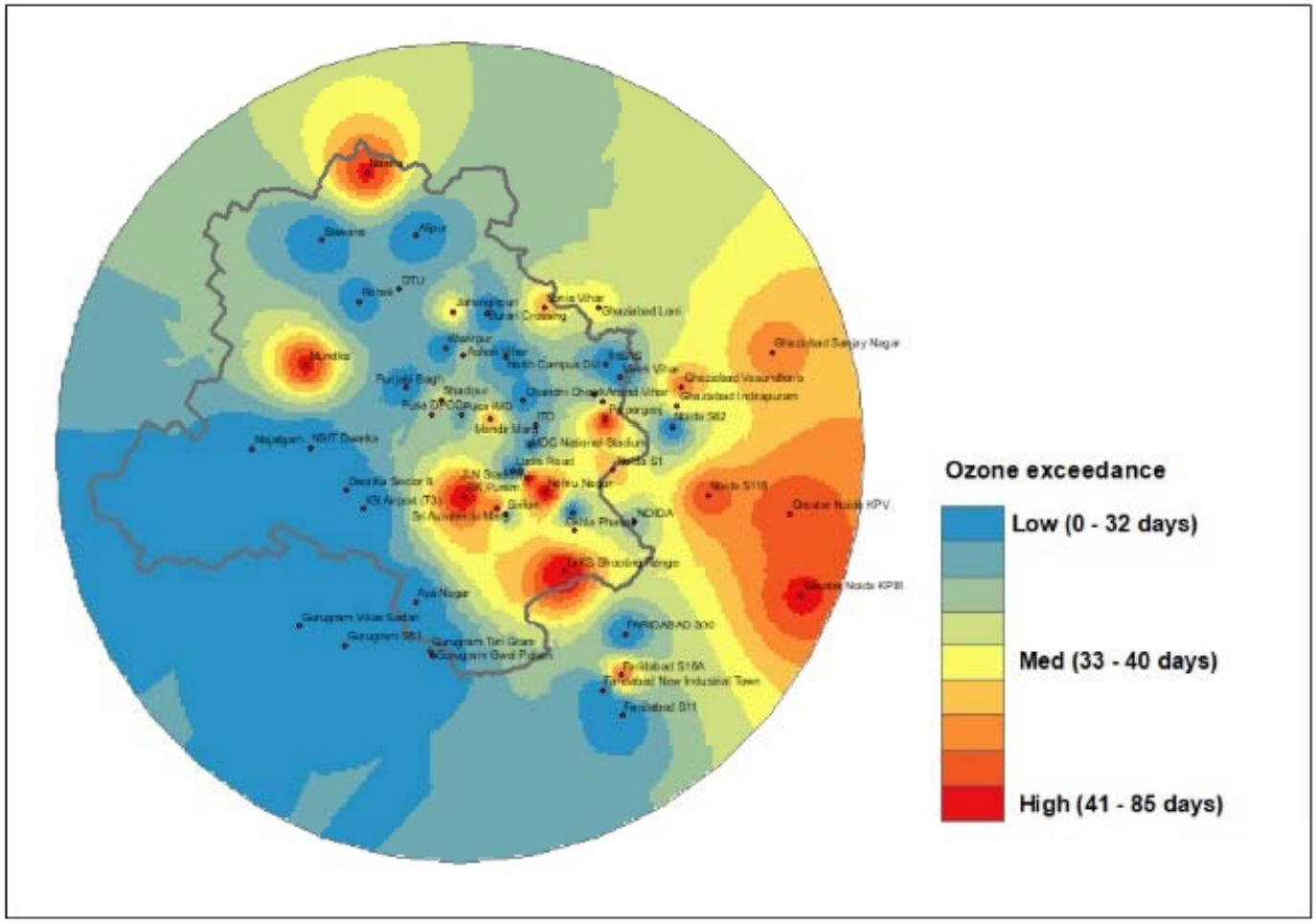
Graph 2: Variation in average duration and spatial spread of daily exceedance during March and April in Delhi-NCR (2019-22)



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. 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.

New Delhi and South Delhi neighbourhoods are worst affected by ground-level ozone pollution

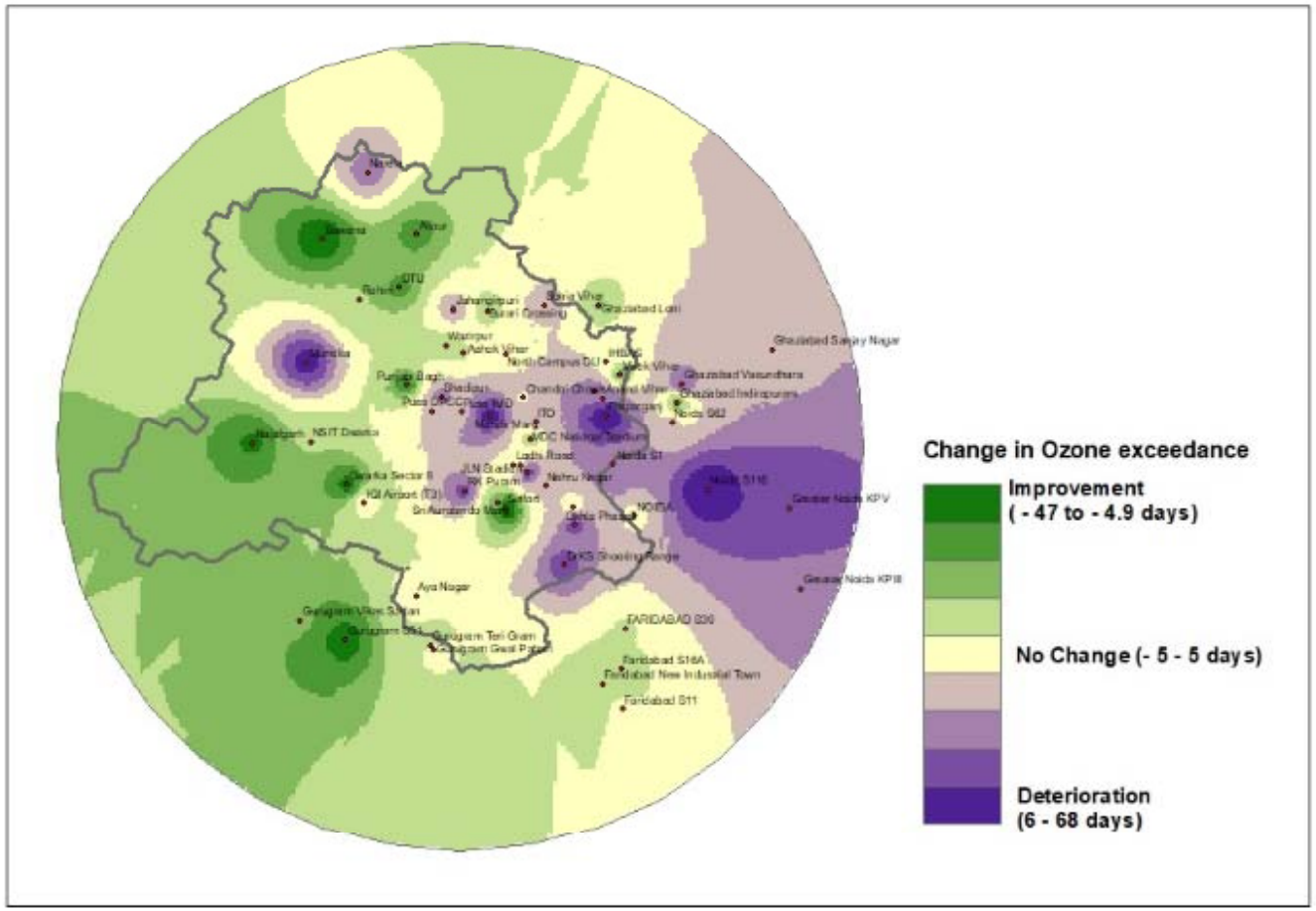
Map 1: Hotspots of ground-level ozone exceedance in Delhi-NCR (March-May 2022)



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.

East and Central Delhi along with Noida are facing worsening trend

Map 2: Change in hotspots of ground-level ozone exceedance in Delhi-NCR (March-May 2022 vs baseline)

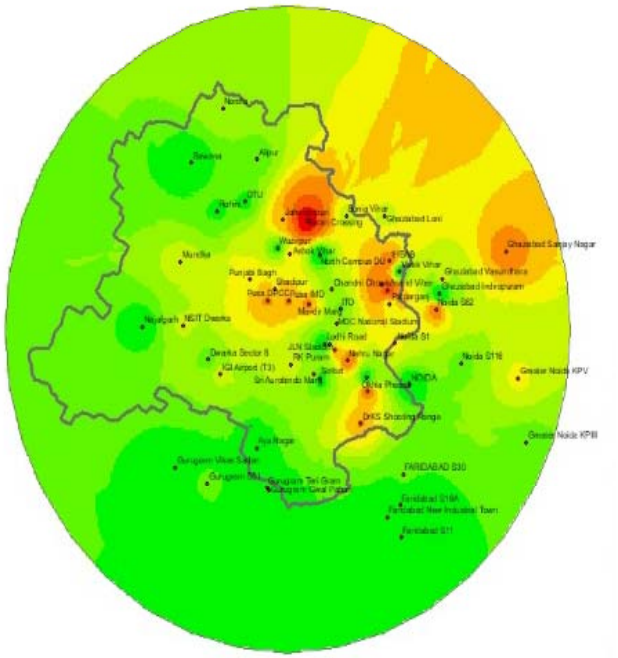


Note: Based on exceedances recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. Baseline is defined as average of 2019, 2020, and 2021. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

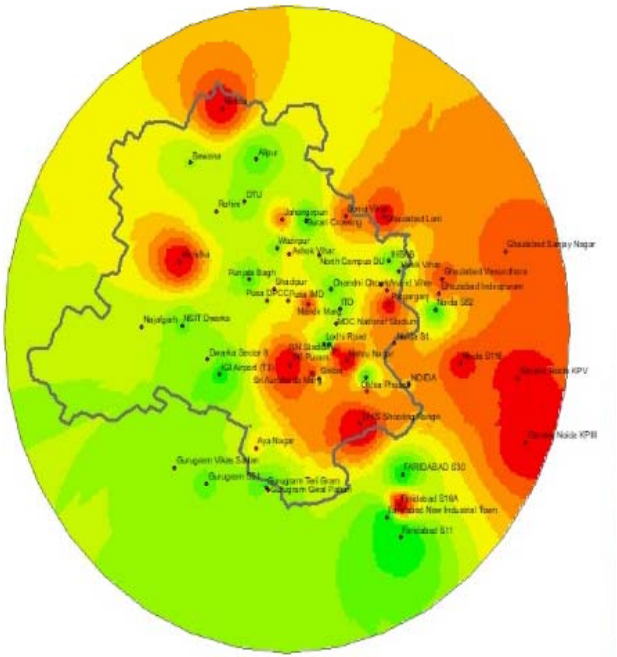
Ground-level ozone hotspots are located in the areas with low levels of NO2 and PM2.5

Map 3: Spatial relationship among hotspots for key pollutants in Delhi-NCR (March-May 2022)

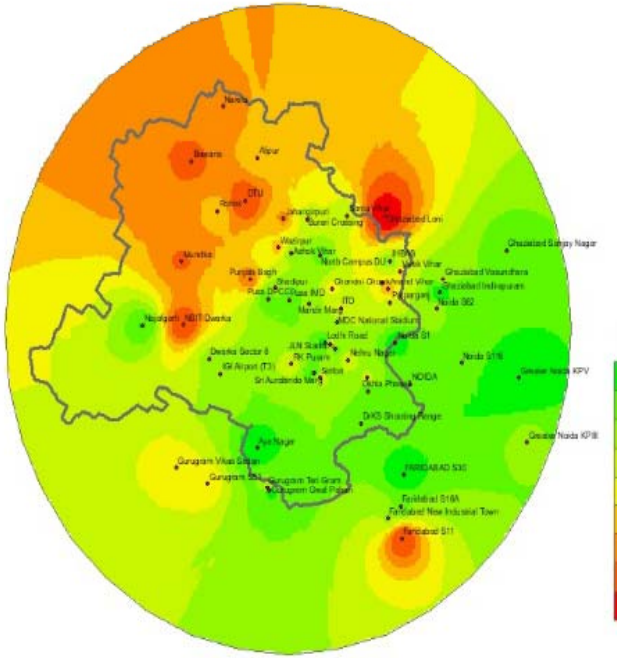
NO2 hotspots



Ozone hotspots



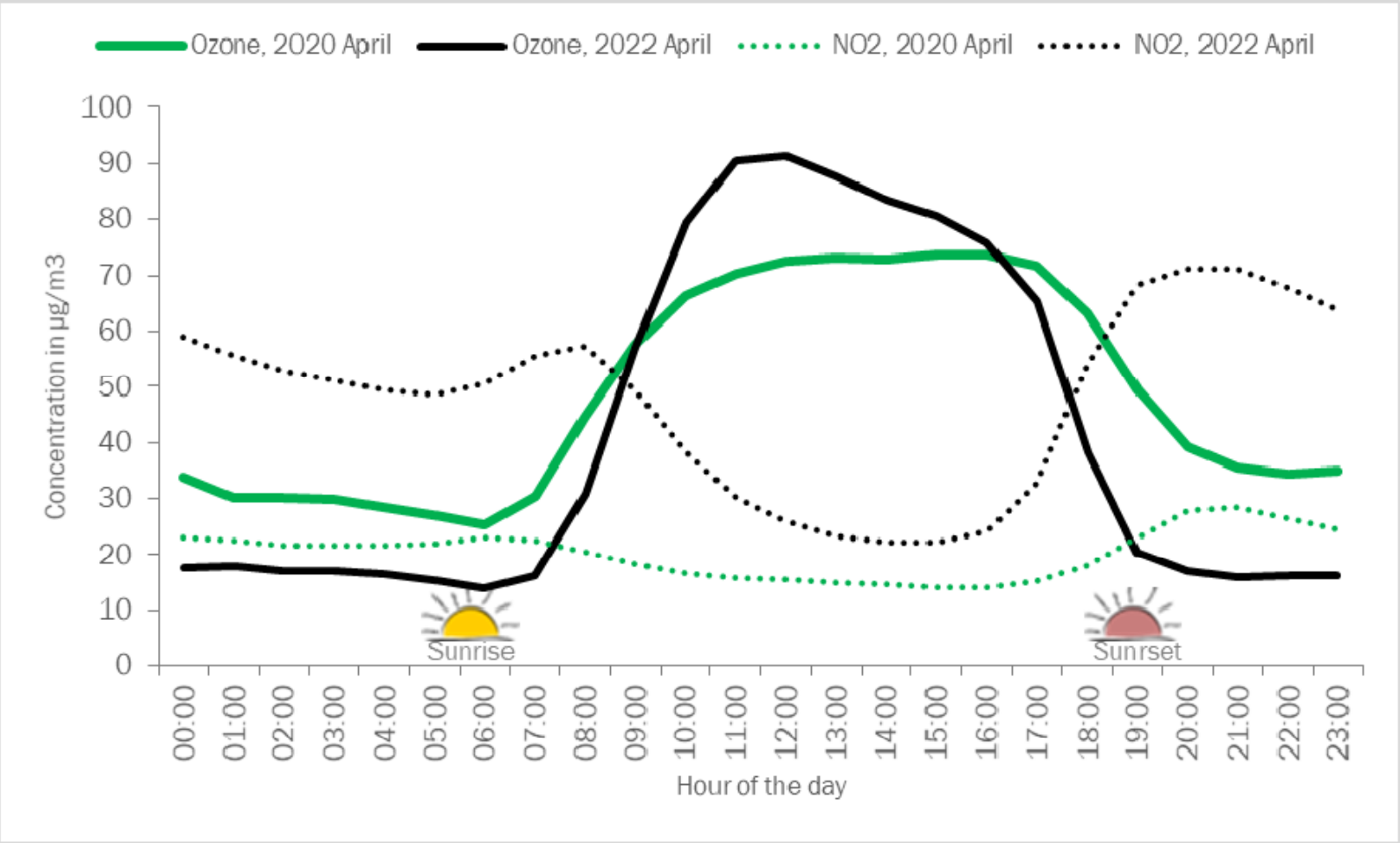
PM2.5 hotspots



Note: Seasonal average computed as mean of monthly averages based on daily 24-hr average for PM2.5 and NO2, while daily maximum 8-hr average is used for ground-level ozone. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

Hourly ozone peak level are up by 23 per cent compared to lockdown times

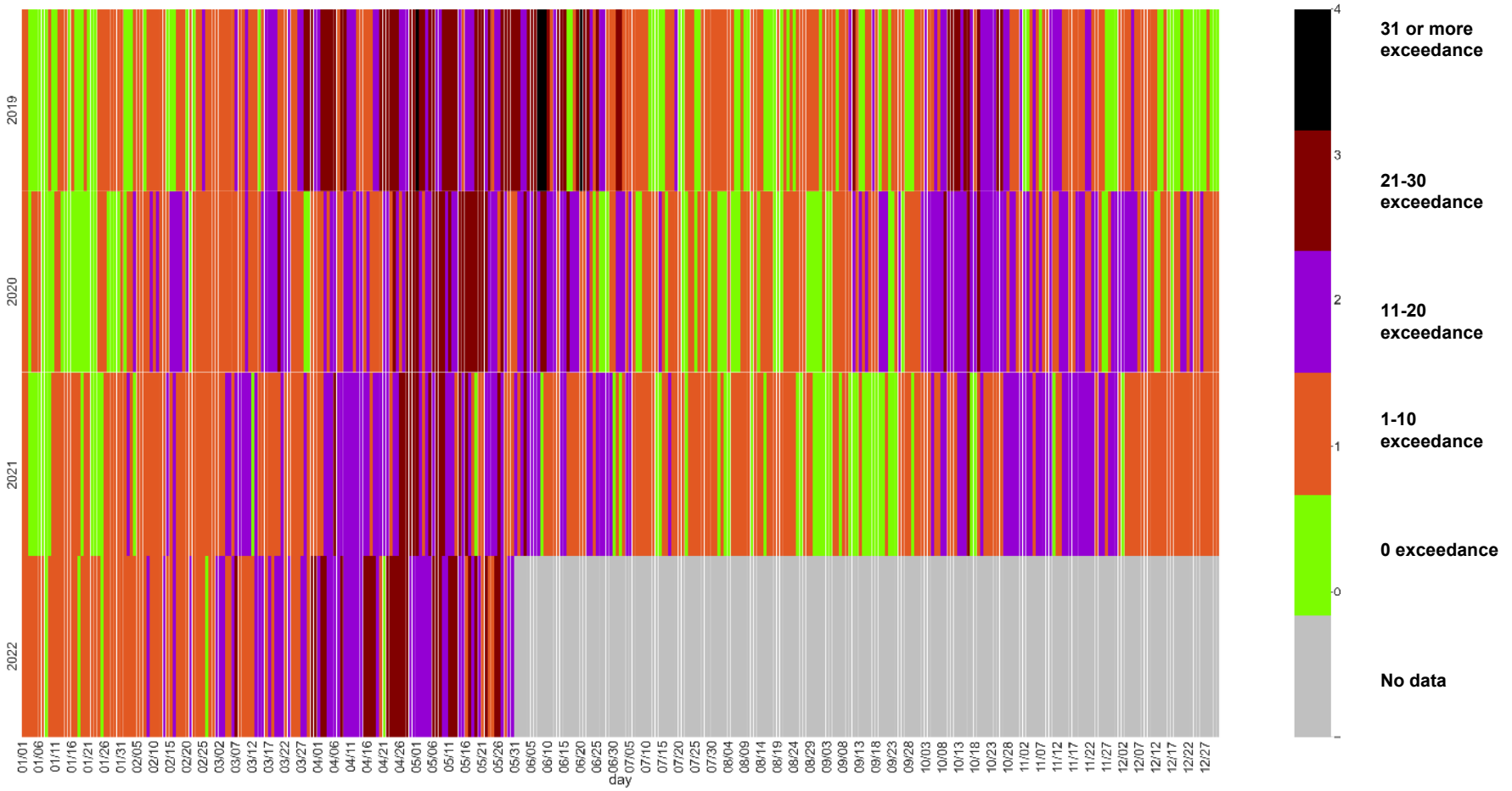
Graph 3: Hourly cycle of ground level ozone and NO2 in Delhi-NCR – 2020 lockdowns v/s 2022 heatwaves



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

Ground-level ozone has become a yearlong problem

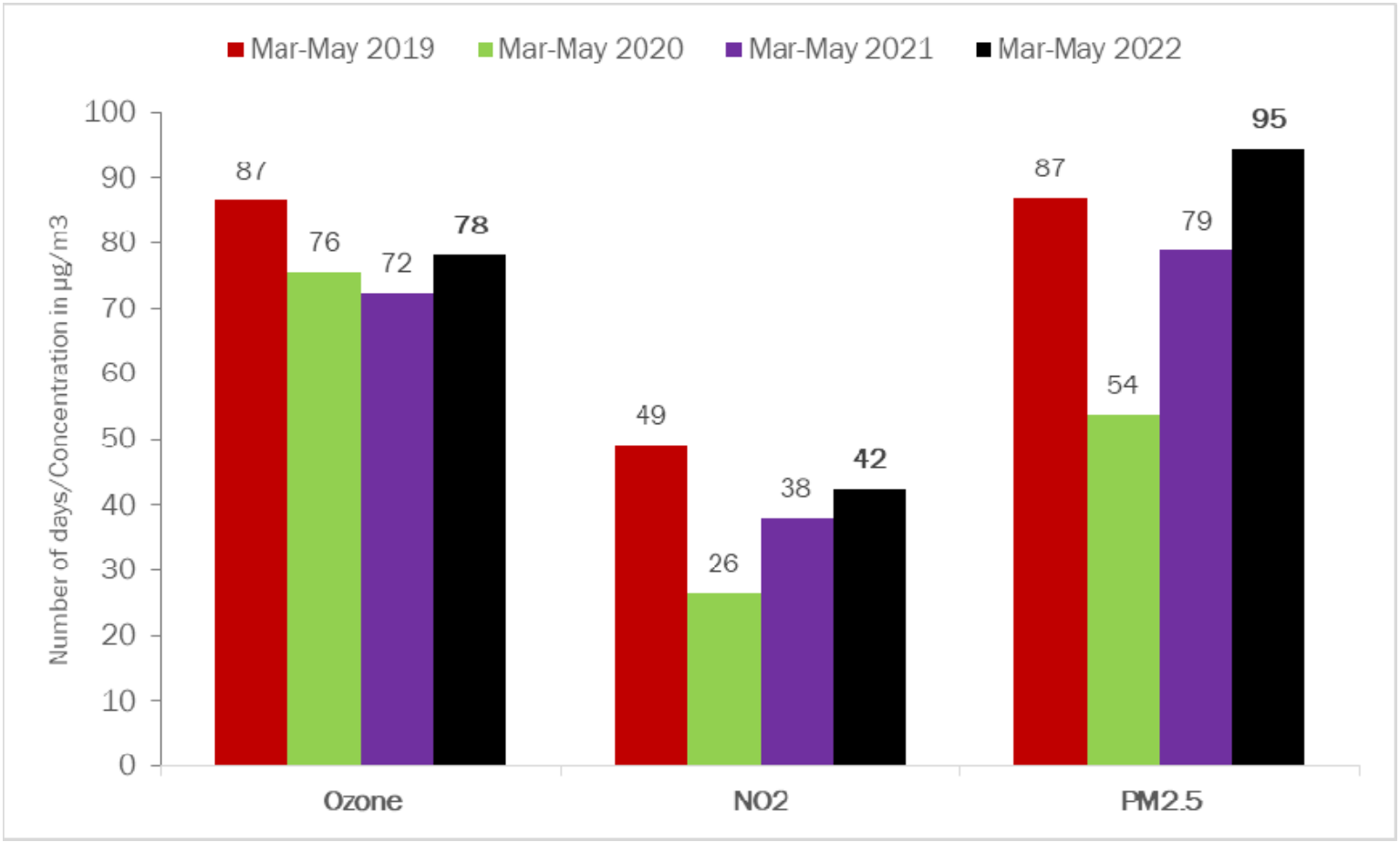
Graph 5: Map of spatiotemporal variation in ground-level ozone in Delhi-NCR (2019-22)



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. Data till 30 May 2022.
Colour coding: Green = 0 exceedance; Orange = 1-10 stations exceed the standard; Violet = 11-20 stations exceed the standard; Maroon = 21-30 stations exceed the standard; Black = 31 or more stations exceed the standard; Grey = No data.
Source: CSE analysis of CPCB realtime data.

During the summer of 2022 all key pollutants have increased in Delhi-NCR

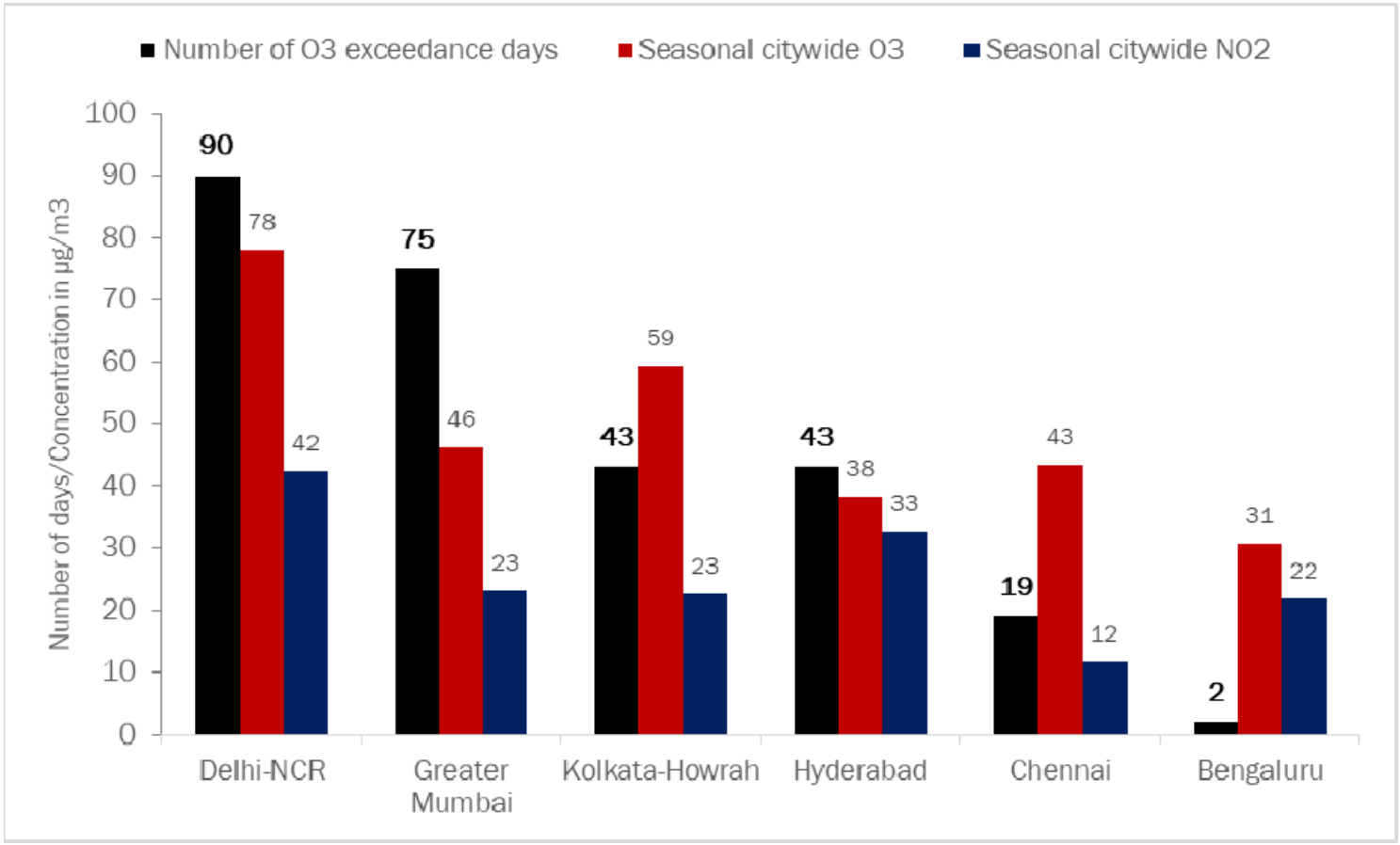
Graph 6: Seasonal levels of key pollutants (PM2.5, NO2, and ground-level ozone) in Delhi-NCR (2019-22)



Note: Based on mean of seasonal average recorded at the monitoring stations at Delhi, Gurugram, Faridabad, Ghaziabad, Noida and Greater Noida. Daily value for PM2.5 and NO2 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. All values are in µg/m3. Data till 30 May 2022.
Source: CSE analysis of CPCB realtime data.

Delhi and Mumbai have severe ground-level ozone problem, but other metros not safe either

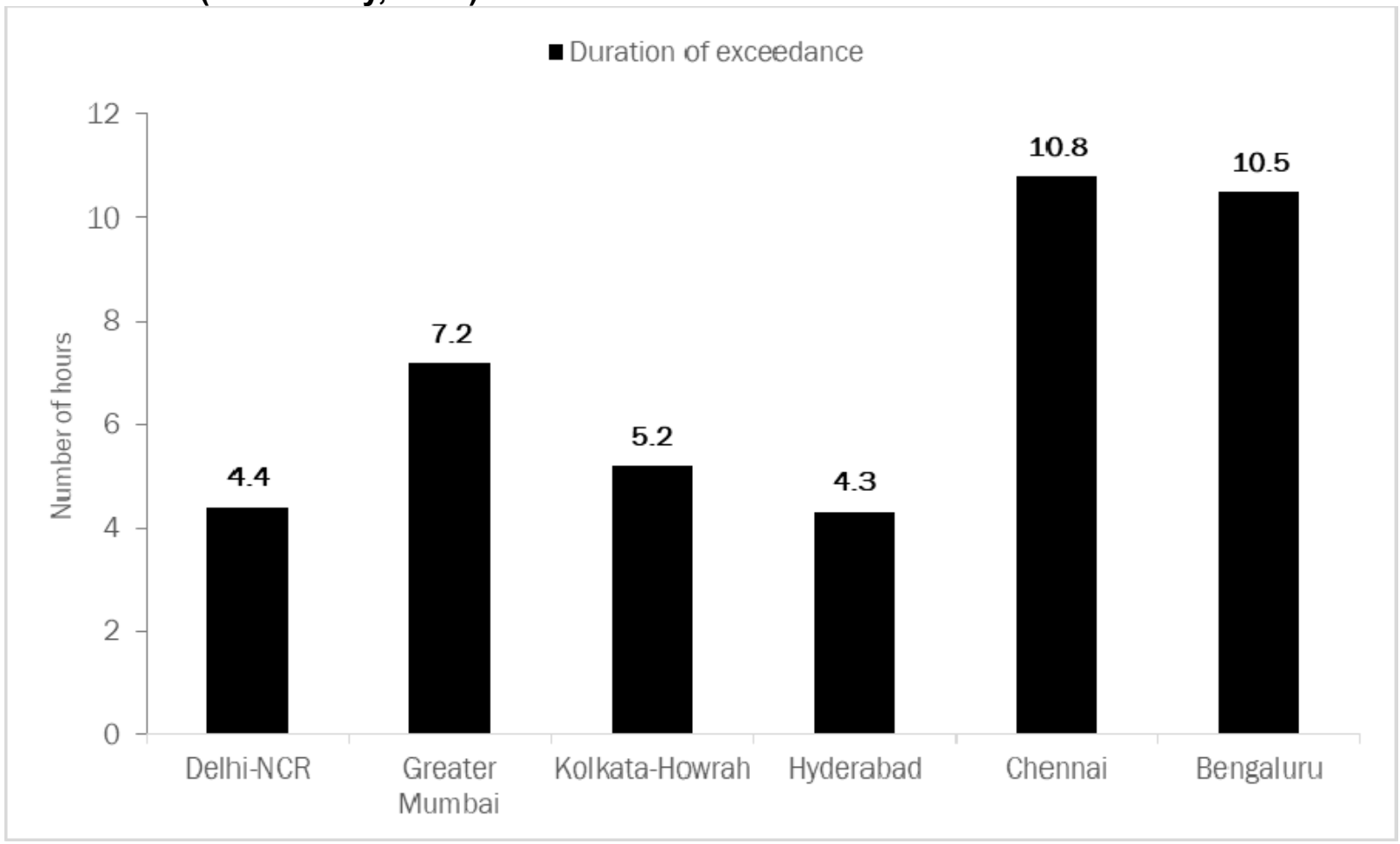
Graph: Comparison of ground-level ozone pollution among the metro cities (March-May, 2022)



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

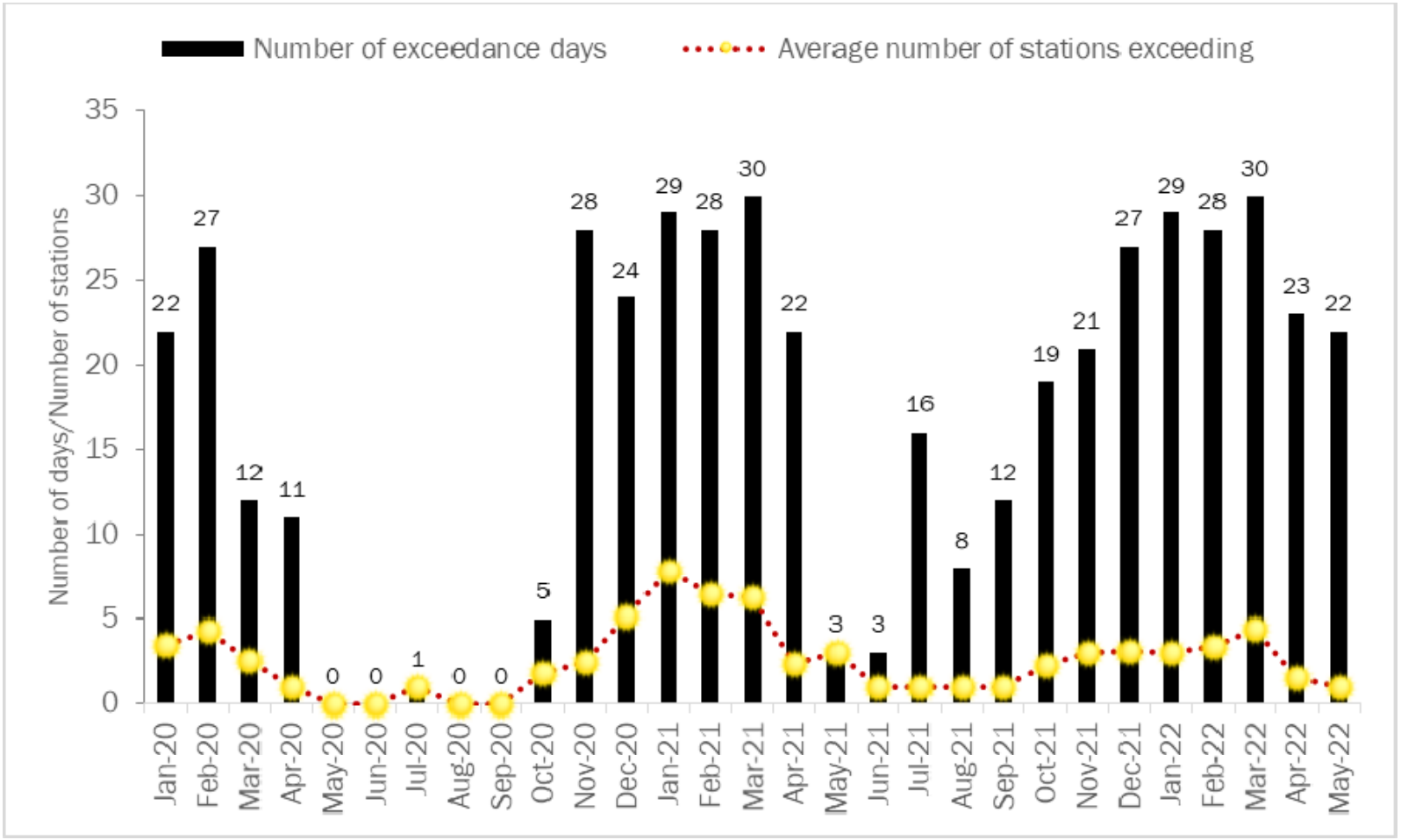
Graph: Comparison of average duration of ground-level ozone exceedance among the metro cities (March-May, 2022)



Note: Exceedance is computed as daily maximum 8-hr average crossing the ground-level ozone 8-hr standard, i.e. 100 µg/m3. 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

For Mumbai ground-level ozone is becoming a yearlong problem

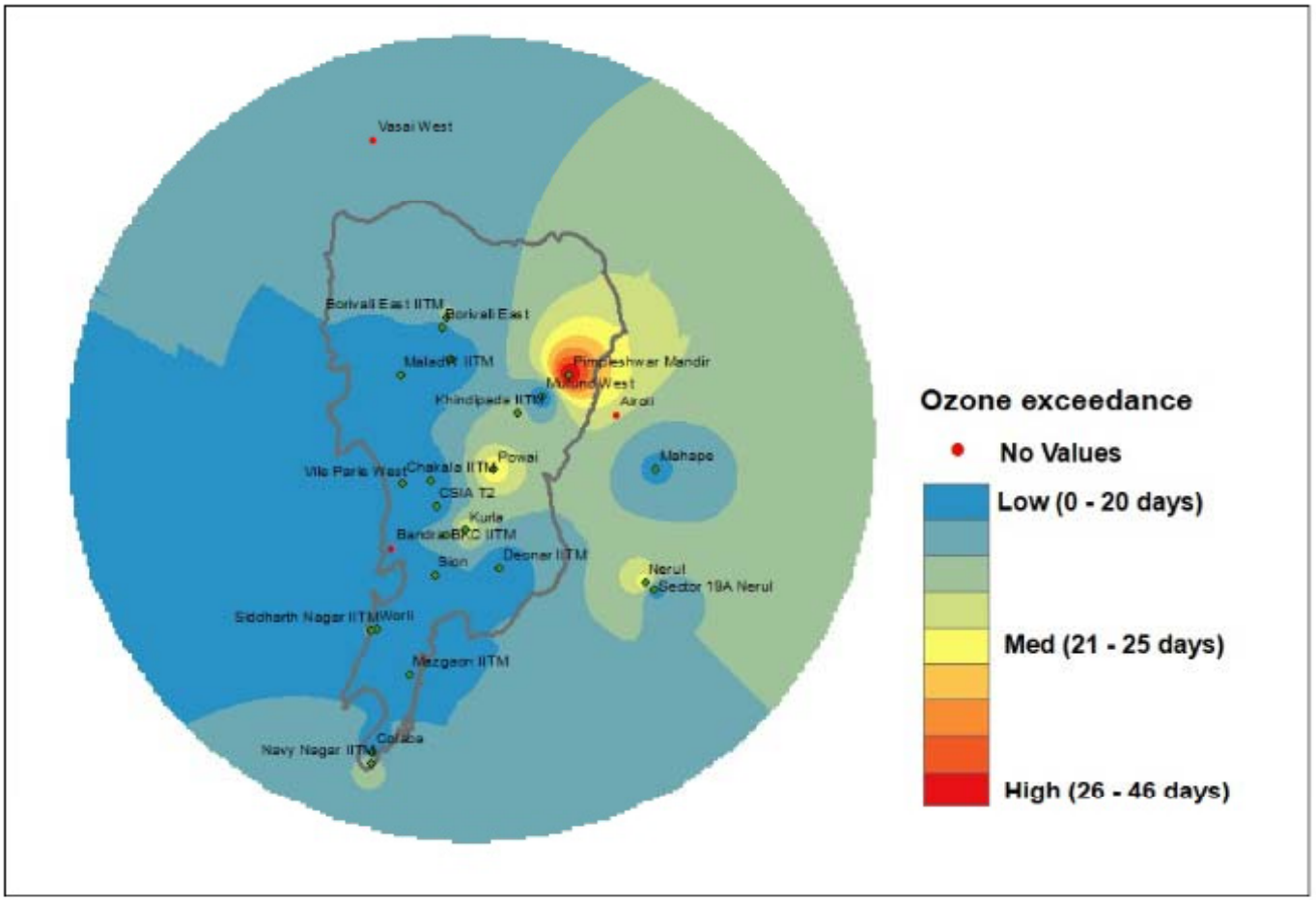
Graph: Monthly variation in ground-level ozone in Greater Mumbai (2020-22)



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.

Mumbai: Thane, Powai and Navi Mumbai are the worst affected by ground-level ozone pollution

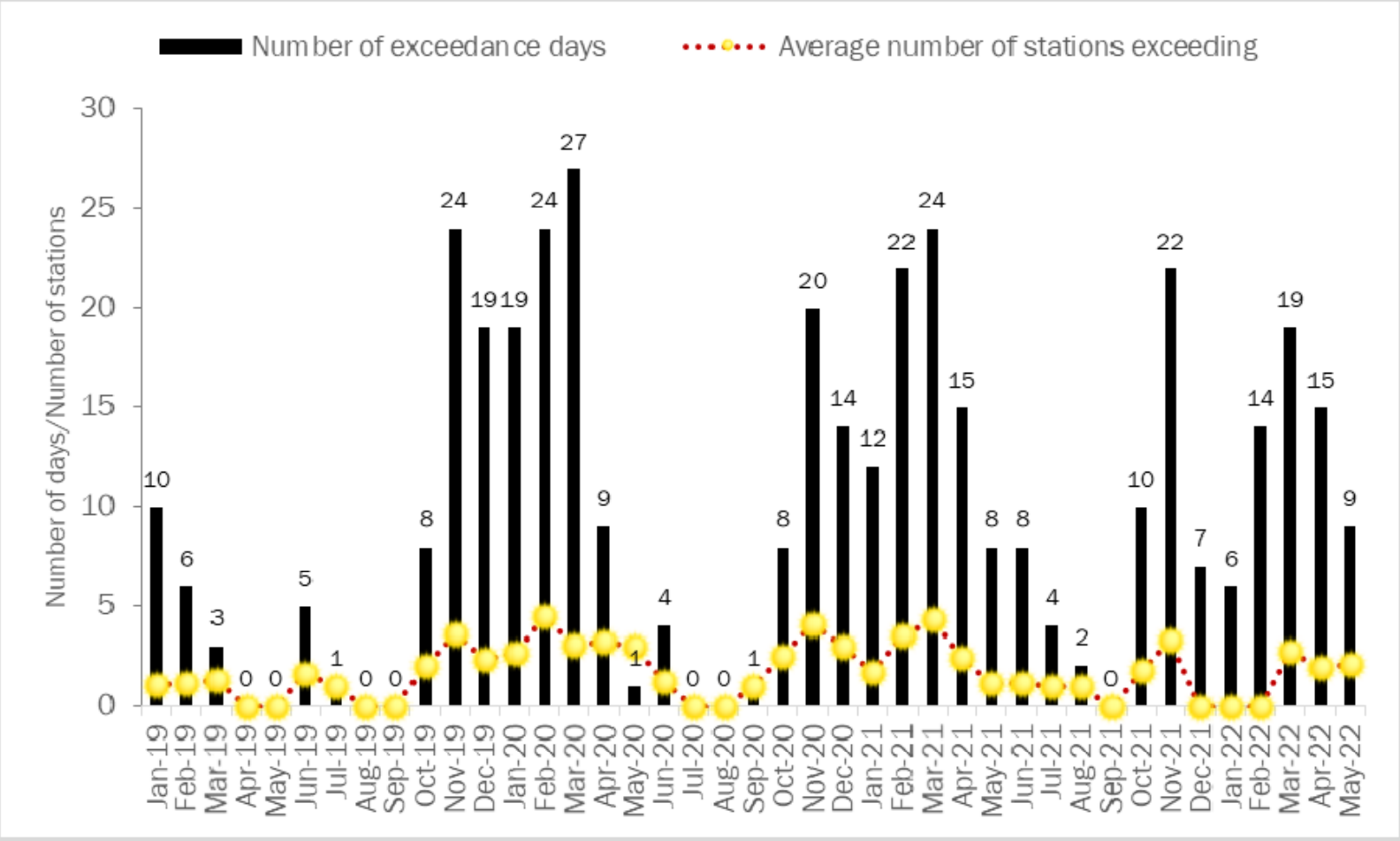
Map: Hotspots of ground-level ozone exceedance in Greater Mumbai (March-May 2022)



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.

For Kolkata ground-level ozone is lesser this summer but it has become a yearlong problem

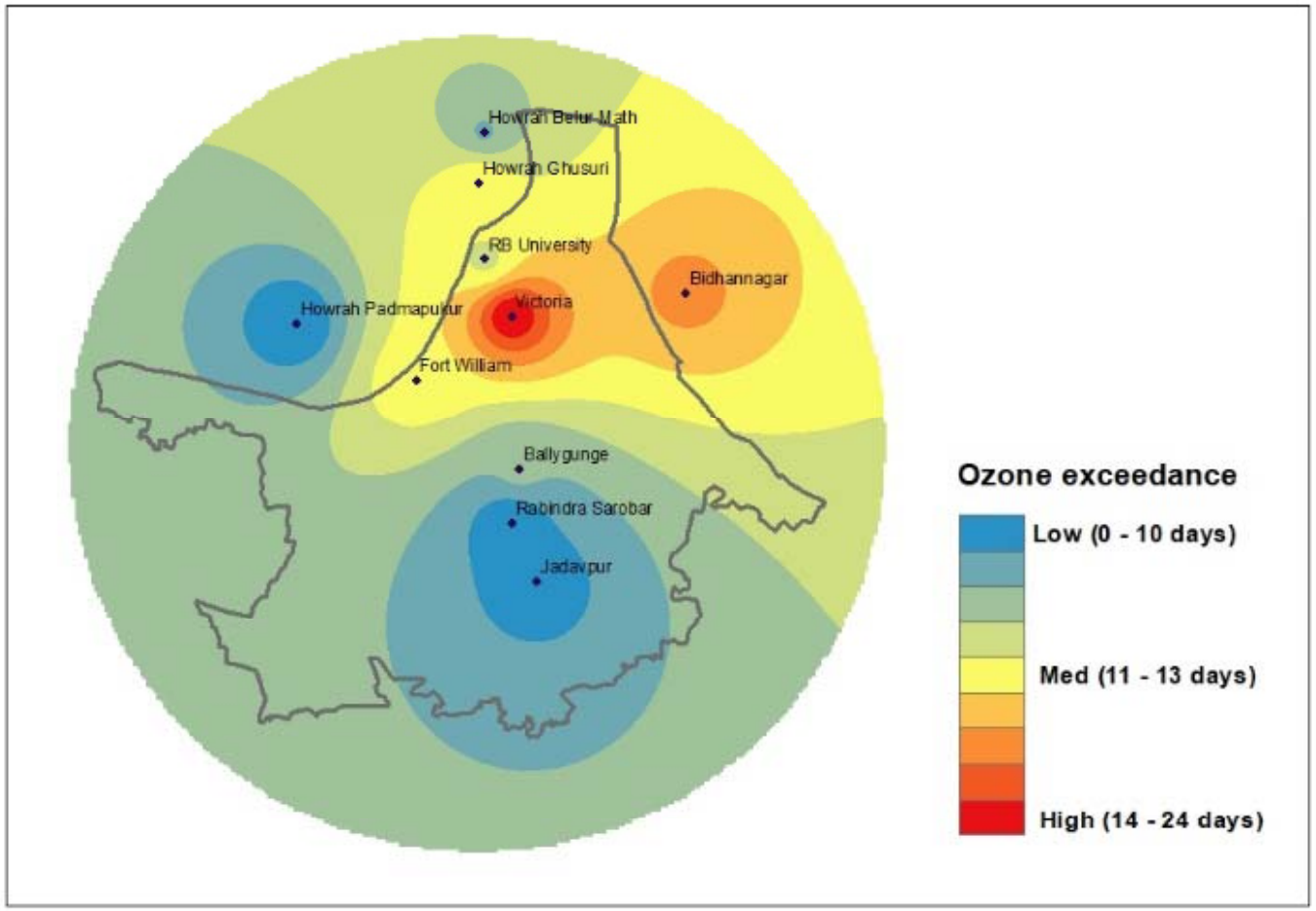
Graph: Monthly variation in ground-level ozone in Greater Kolkata (2019-22)



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.

Kolkata: Victoria is the worst affected by ground-level ozone pollution

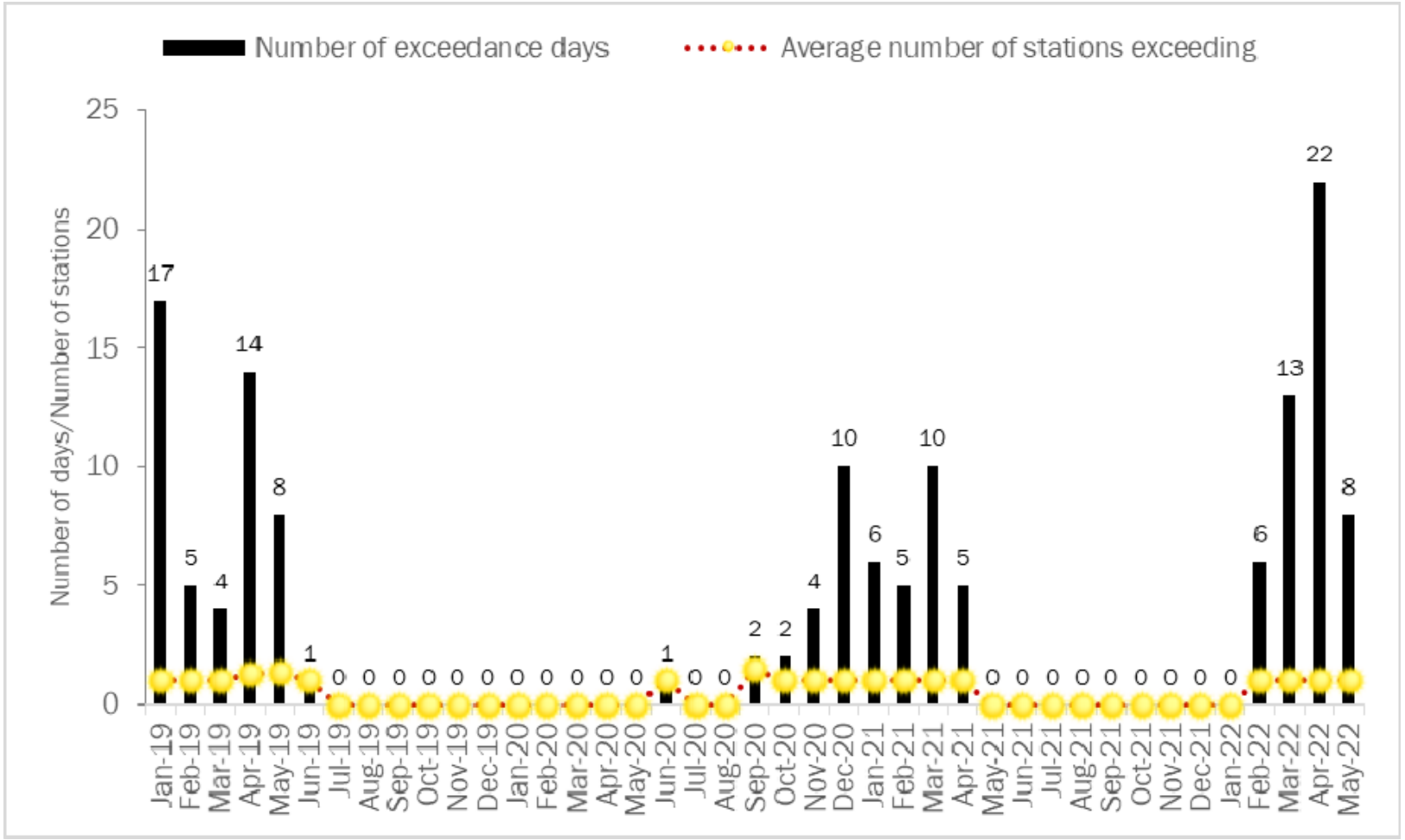
Map: Hotspots of ground-level ozone exceedance in Greater Kolkata (March-May 2022)



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.

For Hyderabad ground-level ozone almost tripled this summer

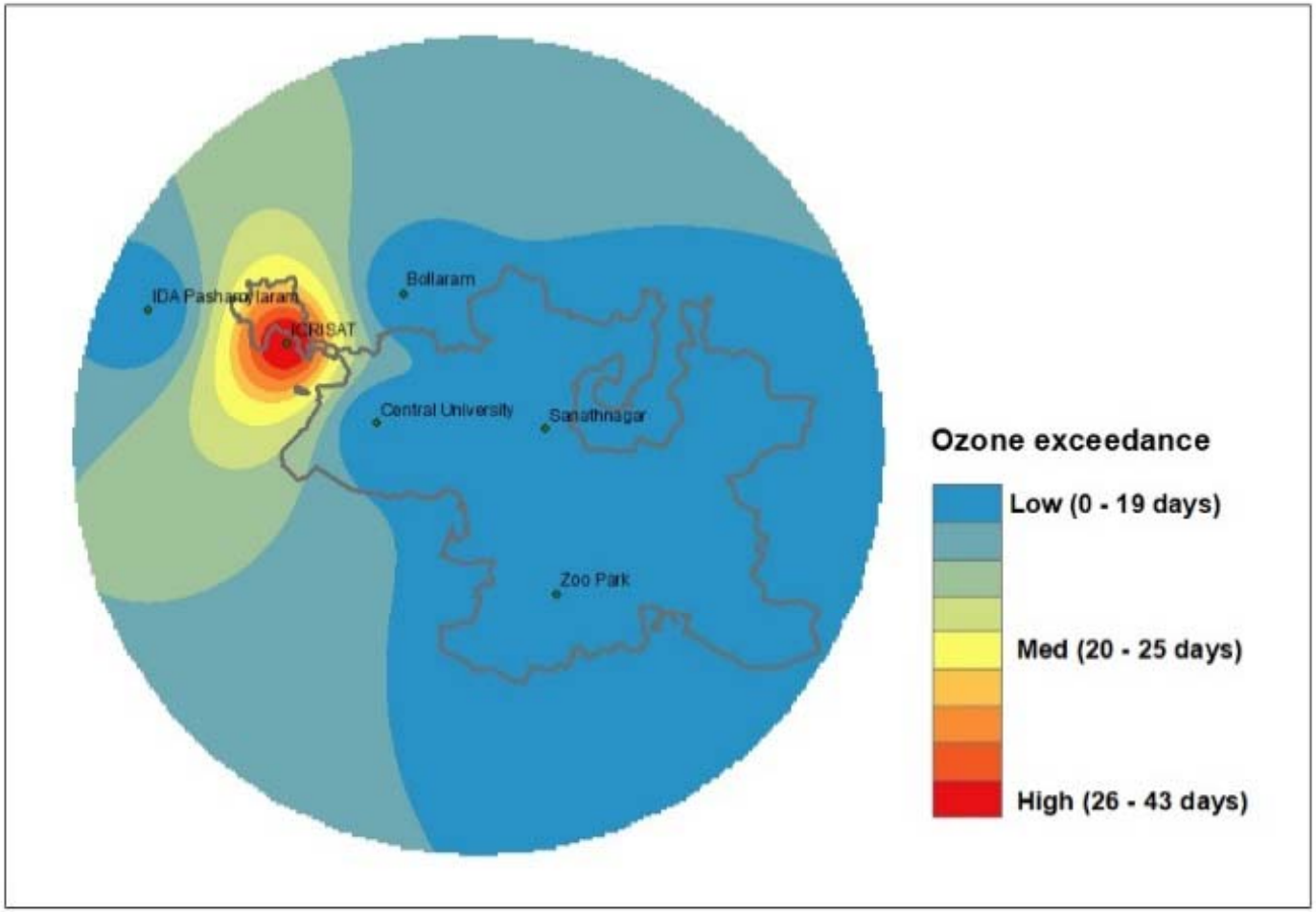
Graph: Monthly variation in ground-level ozone in Hyderabad (2019-22)



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.

Hyderabad: Patancheru is the only neighborhood this summer with ground-level ozone pollution

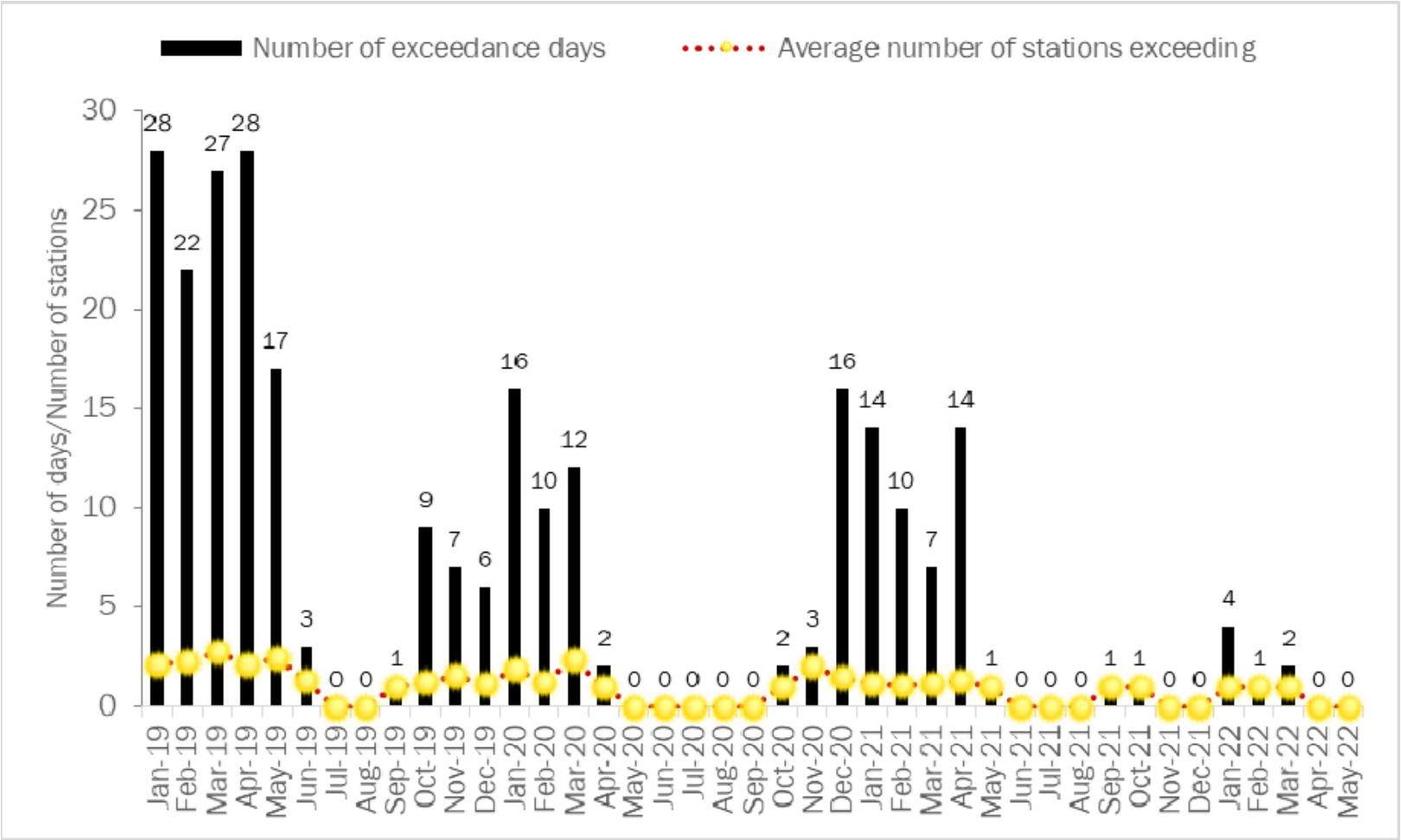
Map: Hotspots of ground-level ozone exceedance in Hyderabad (March-May 2022)



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.

For Bengaluru ground-level ozone exceedance have almost disappeared this summer and winter

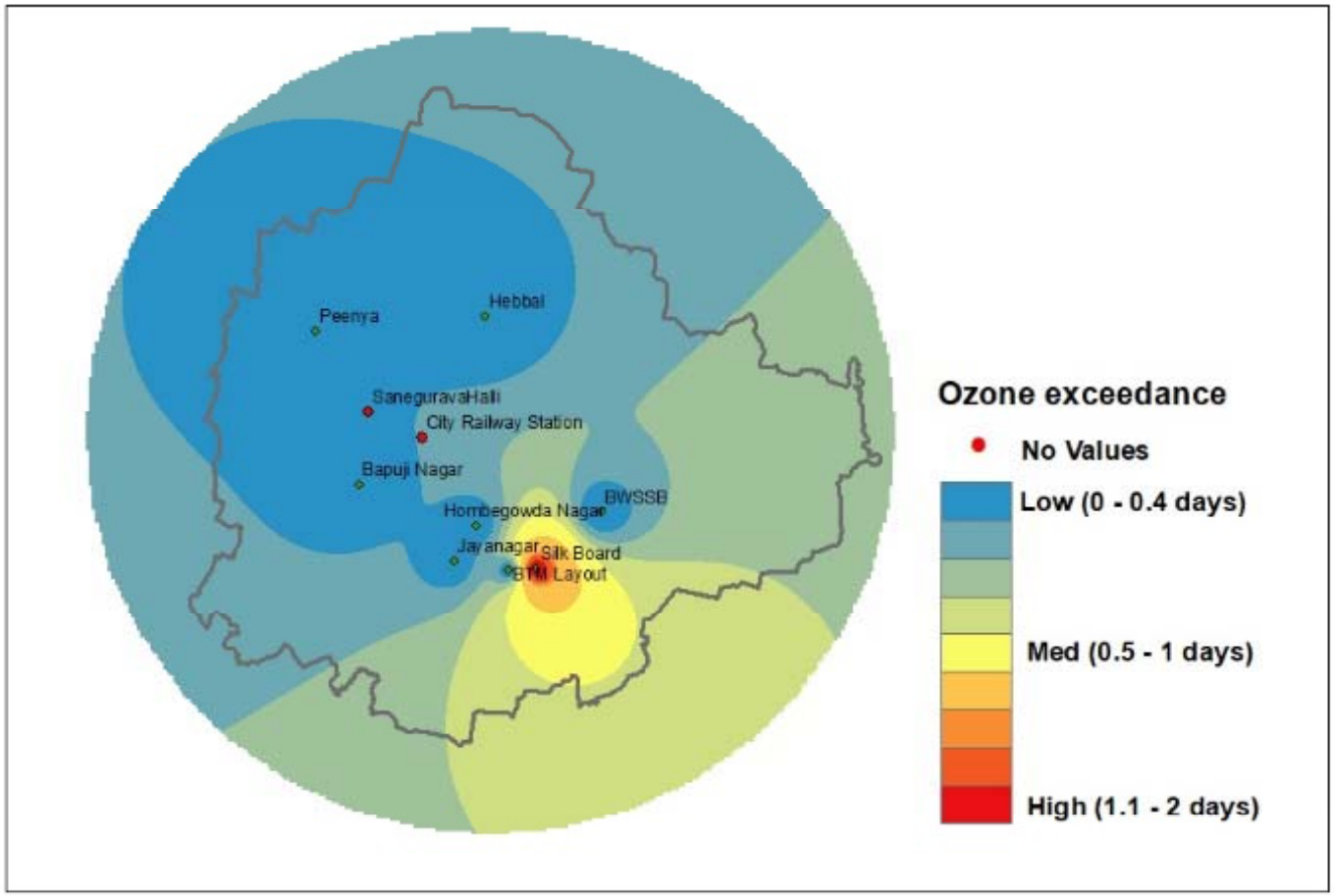
Graph: Monthly variation in ground-level ozone in Bengaluru (2019-22)



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.

Bengaluru: Silk Board is the only neighborhood with ground-level ozone exceedance this summer

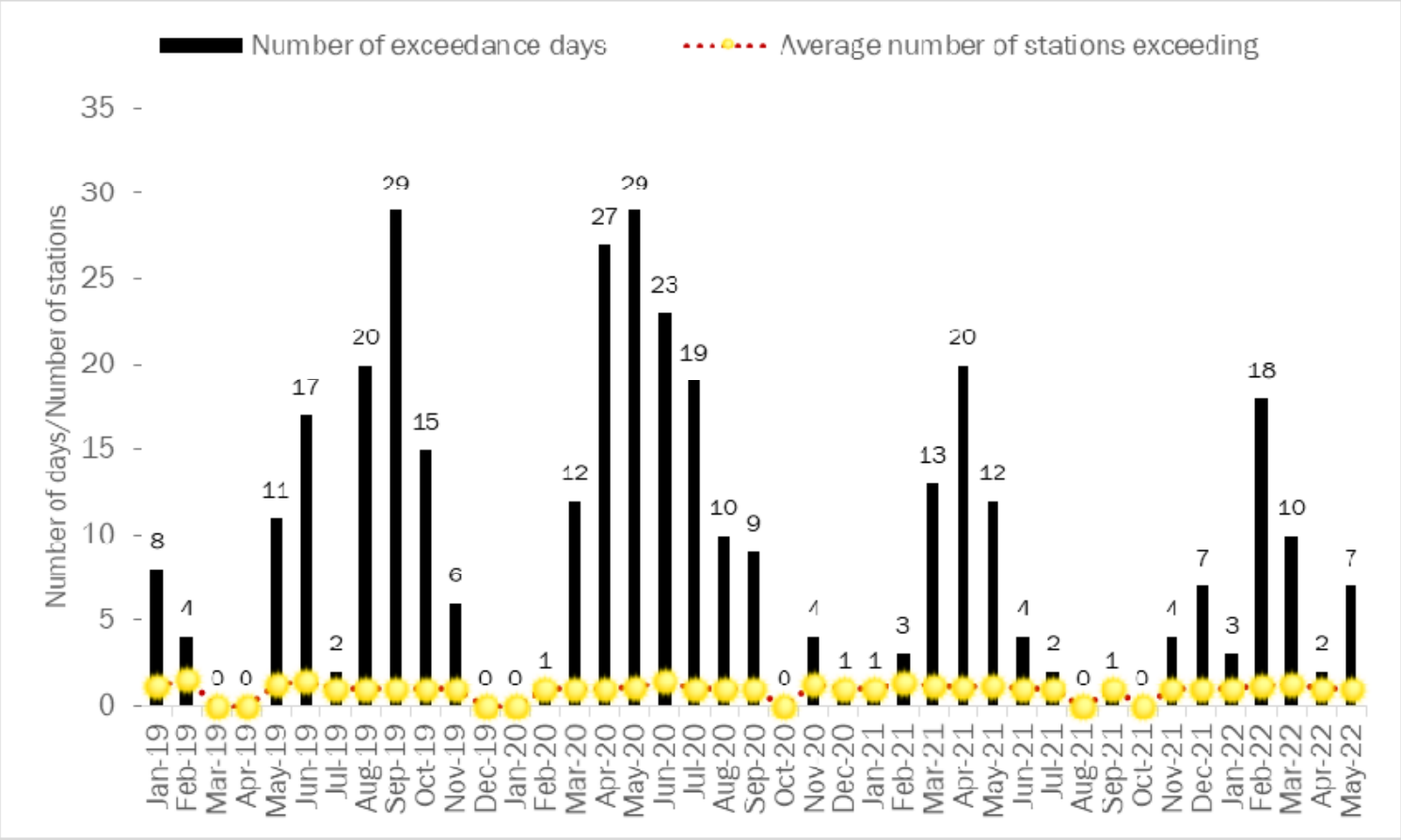
Map: Hotspots of ground-level ozone exceedance in Bengaluru (March-May 2022)



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.

For Chennai ground-level ozone exceedance have declined by almost 60 per cent this summer

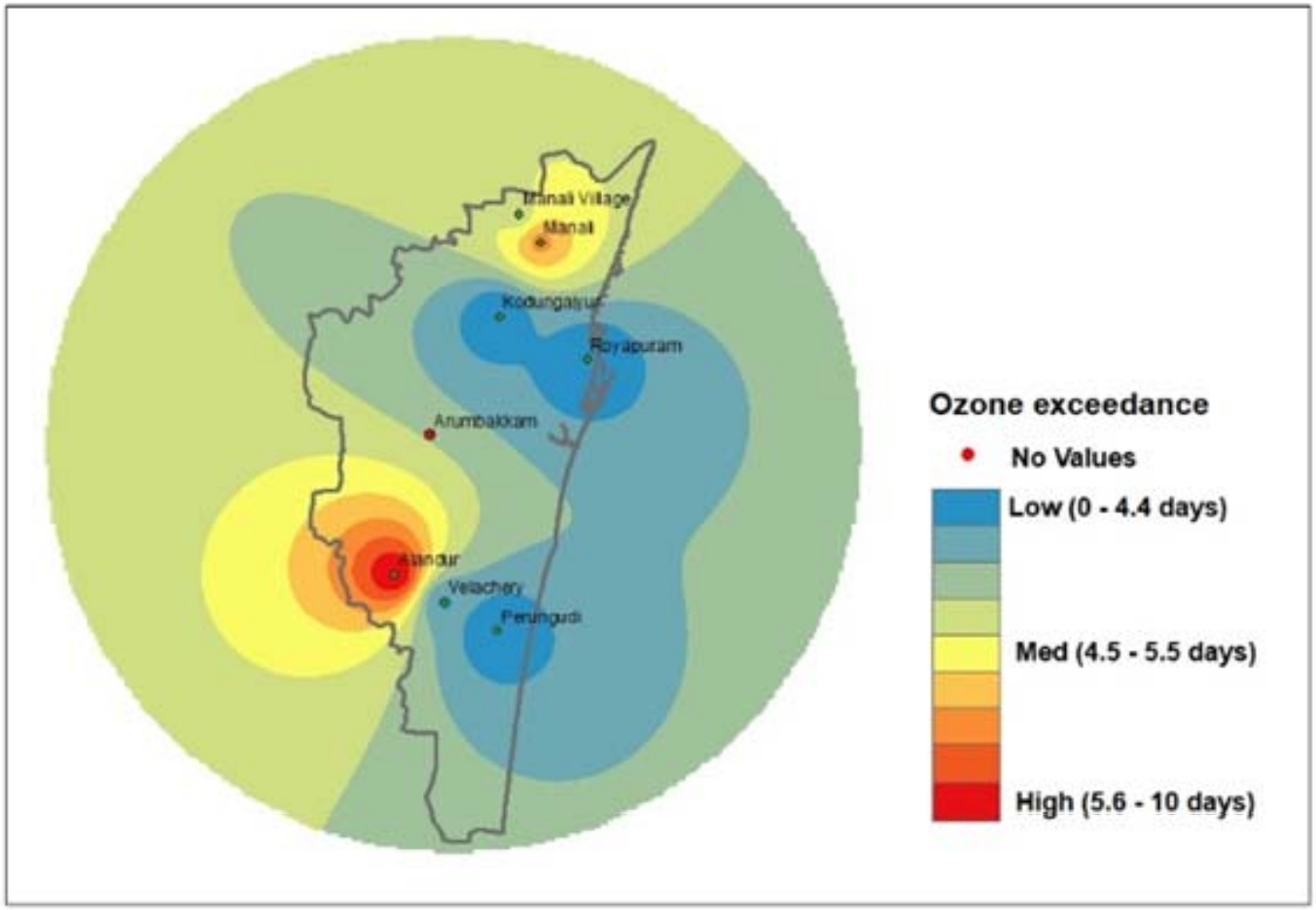
Graph: Monthly variation in ground-level ozone in Chennai (2019-22)



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.

Chennai: Alandur and Manali are the worst affected by ground-level ozone pollution

Map: 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.

But why don’t we see AQI alerts for ground-level ozone?

#1 : AQI design for ground-level ozone is unnecessarily complicated with confusion regarding 1-hr and 8-hr values

Footnote clarifying averaging time change in the ozone AQI sub-index breakpoints is inadequately worded in the National Air Quality Index report and it goes missing from implementation and public communication documents...

Excerpt from National Air Quality Index report, CPCB (2015)

Table 3.11 Breakpoints for AQI Scale 0-500 (units: µg/m³ unless mentioned otherwise)

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m³)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6 –1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748 *	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748 *	34+	1600+	1800+	3.5+

One hourly monitoring (for mathematical calculation only)

Excerpt from About National Air Quality Index, CPCB website
(https://cpcb.nic.in/National-Air-Quality-Index/ accessed on 10-8-2021)

AQI Category	AQI	Concentration range*							
		PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	NH_3	Pb
Good	0 - 50	0 - 50	0 - 30	0 - 40	0 - 50	0 - 1.0	0 - 40	0 - 200	0 - 0.5
Satisfactory	51 - 100	51 - 100	31 - 60	41 - 80	51 - 100	1.1 - 2.0	41 - 80	201 - 400	0.5 - 1.0
Moderately polluted	101 - 200	101 - 250	61 - 90	81 - 180	101 - 168	2.1 - 10	81 - 380	401 - 800	1.1 - 2.0
Poor	201 - 300	251 - 350	91 - 120	181 - 280	169 - 208	10 - 17	381 - 800	801 - 1200	2.1 - 3.0
Very poor	301 - 400	351 - 430	121 - 250	281 - 400	[illegible]	17 - 34	801 - 1600	1201 - 1800	3.1 - 3.5
Severe	401 - [illegible]	430 +	250+	400+	[illegible]	34+	1600+	1800+	3.5+

* CO in mg/m³ and other pollutants in µg/m³; 2h-hourly average values for PM_{10}, $PM_{2.5}$, NO_2, SO_2, NH_3, and Pb, and 8-hourly values for CO and O_3.

Excerpt from SAFAR-India website
(http://safar.tropmet.res.in/AQI-47-12-Details accessed on 10-8-2021)

AQI Category(Range)			PM10 24 - hr (µg/m³)		PM2.5 24 - hr (µg/m³)		NO2 24 - hr (ppb)		O3 8 - hr (ppb)		CO 8 - hr (ppm)	
	I low	I high	C low	C high	C low	C high	C low	C high	C low	C high	C low	C high
Good	0	50	0	50	0	30	0	21	0	25	0.0	0.9
Satisfactory	50	100	50	100	30	60	22	43	26	51	1.0	1.7
Moderate	100	200	100	250	60	90	44	96	52	86	1.8	8.7
Poor	200	300	250	350	90	120	97	149	87	106	8.8	14.8
Very Poor	300	400	350	430	120	250	150	213	107	381	14.9	29.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	382	450	29.8	40

No footnote found

Excerpt from STANDARD OPERATING PROCEDURE (SOP)
Air Quality Monitoring and Forecasting Services, IMD (2021)

Table-3.1: Breakpoints for AQI Scale 0-500 (units: µg/m3 unless mentioned otherwise)

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m³)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6 –1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	431-500	251-350	400+	748+*	34+	1600+	1800+	3.5+

No footnote found

#2 : CPCB's AQI calculation tools do nothing to accommodate the complex design of ground-level ozone.

CPCB's published tools and methodology for calculating AQI have no provision or even mention of 1-hr ozone values despite the top AQI categories for ozone sub-index are exclusively defined by 1-hr values...

Source: https://cpcb.nic.in/national-air-Quality-Index/ accessed on 7-8-2021

Calculation of AQI

Date		Station	NSIT
DD-MM-YYYY		City	Delhi
		State	Delhi

Pollutants		concentration in µg/m3 (except for CO)	Sub-Index	check	Air Quality Index
PM10	24-hr avg	121.00	114	1	
PM2.5	24-hr avg	34.00	57	1	
SO2	24-hr avg	0.00	0	0	
NOx	24-hr avg	8.00	10	1	AQI = 114
*CO (mg/m3)	max 8-hr	0.00	0	0	
O3	max 8-hr	57.00	57	1	
NH3	24-hr avg	34.00	9	1	

* Concentrations of minimum three pollutants are required; one of them should be PM10 or PM2.5
* The check displays "1" when a non-zero value is entered

Good (0–50)	Minimal Impact	Poor (201–300)	Breathing discomfort to people on prolonged exposure
Satisfactory (51–100)	Minor breathing discomfort to sensitive peop	Very Poor (301–400)	Respiratory illness to the people on prolonged exposur
Moderate (101–200)	Breathing discomfort to the people with lung, heart disease, children and older adults	Severe (>401)	Respiratory effects even on healthy people

How is AQI calculated?

1. The Sub-indices for individual pollutants at a monitoring location are calculated using its 24-hourly average concentration value (8-hourly in case of CO and O_3) and health breakpoint concentration range. The worst sub-index is the AQI for that location.
2. All the eight pollutants may not be monitored at all the locations. Overall AQI is calculated only if data are available for minimum three pollutants out of which one should necessarily be either $PM_{2.5}$ or PM_{10}. Else, data are considered insufficient for calculating AQI. Similarly, a minimum of 16 hours' data is considered necessary for calculating sub-index.
3. The sub-indices for monitored pollutants are calculated and disseminated, even if data are inadequate for determining AQI. The Individual pollutant-wise sub-index will provide air quality status for that pollutant.
4. The web-based system is designed to provide AQI on real time basis. It is an automated system that captures data from continuous monitoring stations without human intervention, and displays AQI based on running average values (e.g. AQI at 6am on a day will incorporate data from 6am on previous day to the current day).
5. For manual monitoring stations, an AQI calculator is developed wherein data can be fed manually to get AQI value.

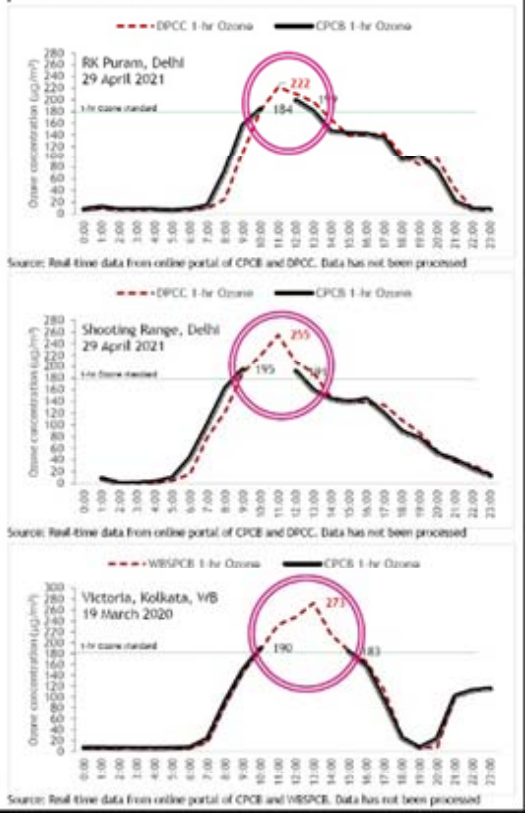
#3 : CPCB is arbitrarily capping data at 200µg/m3 , regardless of the fact that the 1-hr standard is 180 µg/m3.

CPCB is filtering out all ozone values higher than 200 µg/m^3 from the national real-time data portal, filtering happens at 15-minute level. State pollution control board databases show 200+levels for corresponding timestamps...

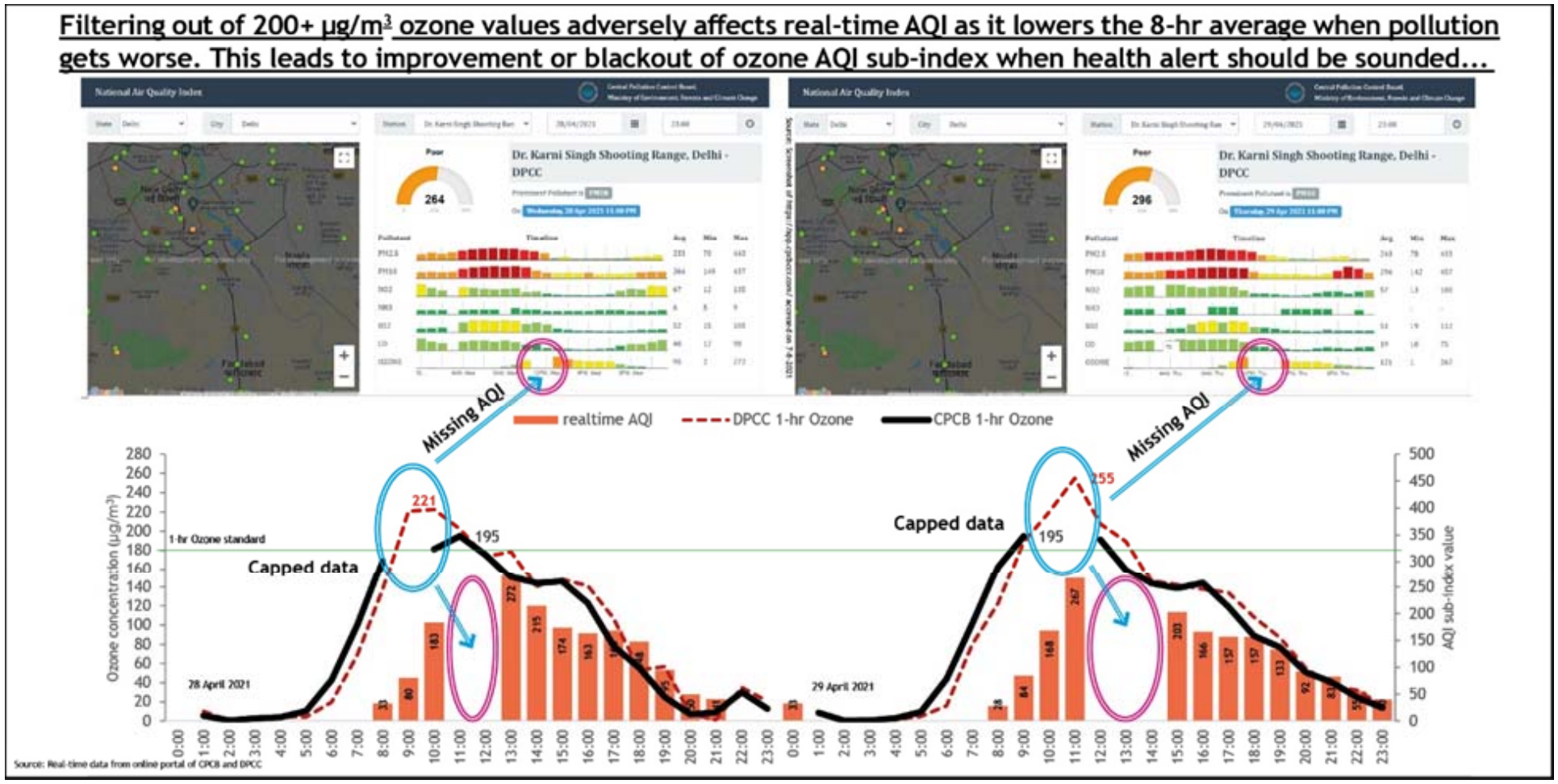
Screenshot of the CPCB portal database for Delhi going blank as levels cross 200 µg/m^3 (https://app.cpcbccr.com/ accessed on 10-8-2021)

S.No	From Date	To Date	Dr. Karni Singh Shooting Range, Delhi - DPCC	R K Puram, Delhi - DPCC	Shillot, Delhi - CPCB	Sri Aurobindo Marg, Delhi - DPCC	Nehru Nagar, Delhi - DPCC
S.No	From Date	To Date	Ozone(ug/m3)	Ozone(ug/m3)	Ozone(ug/m3)	Ozone(ug/m3)	Ozone(ug/m3)
1	28-Apr-2021 - 08:00	28-Apr-2021 - 08:15	84.1	42.1	38.8	62.4	34.8
2	28-Apr-2021 - 08:15	28-Apr-2021 - 08:30	84.7	65.8	65.3	85.6	87.1
3	28-Apr-2021 - 08:30	28-Apr-2021 - 08:45	108.4	83.2	89.0	108.0	95.3
4	28-Apr-2021 - 08:45	28-Apr-2021 - 09:00	127.3	101.9	117.3	124.2	138.5
5	28-Apr-2021 - 09:00	28-Apr-2021 - 09:15	131.2	121.2	131.8	136.2	167.2
6	28-Apr-2021 - 09:15	28-Apr-2021 - 09:30	141.3	146.3	170.3	151.8	182.1
7	28-Apr-2021 - 09:30	28-Apr-2021 - 09:45	170.8	174.6		171.8	
8	28-Apr-2021 - 09:45	28-Apr-2021 - 10:00	181.4	183.1		194.8	
9	28-Apr-2021 - 10:00	28-Apr-2021 - 10:15	194.8	194.4			
10	28-Apr-2021 - 10:15	28-Apr-2021 - 10:30					
11	28-Apr-2021 - 10:30	28-Apr-2021 - 10:45					
12	28-Apr-2021 - 10:45	28-Apr-2021 - 11:00					
13	28-Apr-2021 - 11:00	28-Apr-2021 - 11:15					
14	28-Apr-2021 - 11:15	28-Apr-2021 - 11:30					
15	28-Apr-2021 - 11:30	28-Apr-2021 - 11:45					
16	28-Apr-2021 - 11:45	28-Apr-2021 - 12:00					
17	28-Apr-2021 - 12:00	28-Apr-2021 - 12:15					
18	28-Apr-2021 - 12:15	28-Apr-2021 - 12:30					
19	28-Apr-2021 - 12:30	28-Apr-2021 - 12:45					
20	28-Apr-2021 - 12:45	28-Apr-2021 - 13:00		198.2			
21	28-Apr-2021 - 13:00	28-Apr-2021 - 13:15		184.1		182.5	
22	28-Apr-2021 - 13:15	28-Apr-2021 - 13:30		177.2		184.3	
23	28-Apr-2021 - 13:30	28-Apr-2021 - 13:45	183.3	183.6		182.8	
24	28-Apr-2021 - 13:45	28-Apr-2021 - 14:00	188.8	174.9		188.9	
25	28-Apr-2021 - 14:00	28-Apr-2021 - 14:15	176.2	160.2	180.2	173.5	
26	28-Apr-2021 - 14:15	28-Apr-2021 - 14:30	160.6	143.0	161.3	162.5	186.2
27	28-Apr-2021 - 14:30	28-Apr-2021 - 14:45	154.4	138.4	167.3	162.8	179.7
28	28-Apr-2021 - 14:45	28-Apr-2021 - 15:00	143.4	138.9	168.8	152.0	178.1
29	28-Apr-2021 - 15:00	28-Apr-2021 - 15:15	146.4	141.1	168.2	149.6	161.3
30	28-Apr-2021 - 15:15	28-Apr-2021 - 15:30	143.7	140.2	164.8	142.7	168.3
31	28-Apr-2021 - 15:30	28-Apr-2021 - 15:45	144.8	147.4	167.2	148.8	184.0
32	28-Apr-2021 - 15:45	28-Apr-2021 - 16:00	139.8	141.8	162.0	146.2	179.8

Comparison of CPCB database with State pollution control board databases



#4 : This practice not only stops ozone AQI from going beyond “Moderate” category, it lowers the AQI when pollution gets worst.



Act Now!!!

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

Immediately, refine the action strategy for combined control of particulate pollution, ozone and its precursor gases like NOx to maximise the co-benefits of the action plan. At the national level, the National Clean Air Programme needs to propose specific measures to control ozone precursor gases including NOx, volatile organic compound, carbon monoxide etc that are emitted largely from vehicles and industry.

Simultaneously develop a robust public information and dissemination system to alert public about ozone exceedance wherever ozone build up is happening for exposure management. This will also require refining the current Air Quality Index.