

## CSE Analysis

### Decoding winter smog so far to expose new patterns

**New Delhi, December 2, 2020:** New analysis of the winter pollution until November this year by the Centre for Science and Environment (CSE) shows how clean air gains of the lockdown and monsoon period were lost with the reopening of the economy and hostile winter weather. While this was expected, the deep dive analysis of the realtime data from monitoring stations across Delhi NCR and Delhi expose the changing pattern of winter pollution.

Even though the overall average level of PM<sub>2.5</sub> for the 11 months in 2020 is considerably lower than the previous year, the PM<sub>2.5</sub> levels in winter spiked to very poor to severe levels across Delhi NCR. This is a typical and predictable winter trend when continuous emissions from local sources and episodic pollution from biomass burning get trapped due to meteorological changes. But this year there is a change in the pattern that shows up in lesser number of smog episodes compared to last year, wider variation on location-wise concentration with more lower bound ranges compared to last year, higher number of days with greater contribution from the stubble burning among others. There are also days when pollution levels have dropped to moderate level even without rains but better wind conditions.

This only indicates towards the fact that the deep dive reforms and action in key sectors of pollution – vehicles, industry, power plants and waste management – will have to be scaled up at speed across the region to further bend the annual air pollution curve.

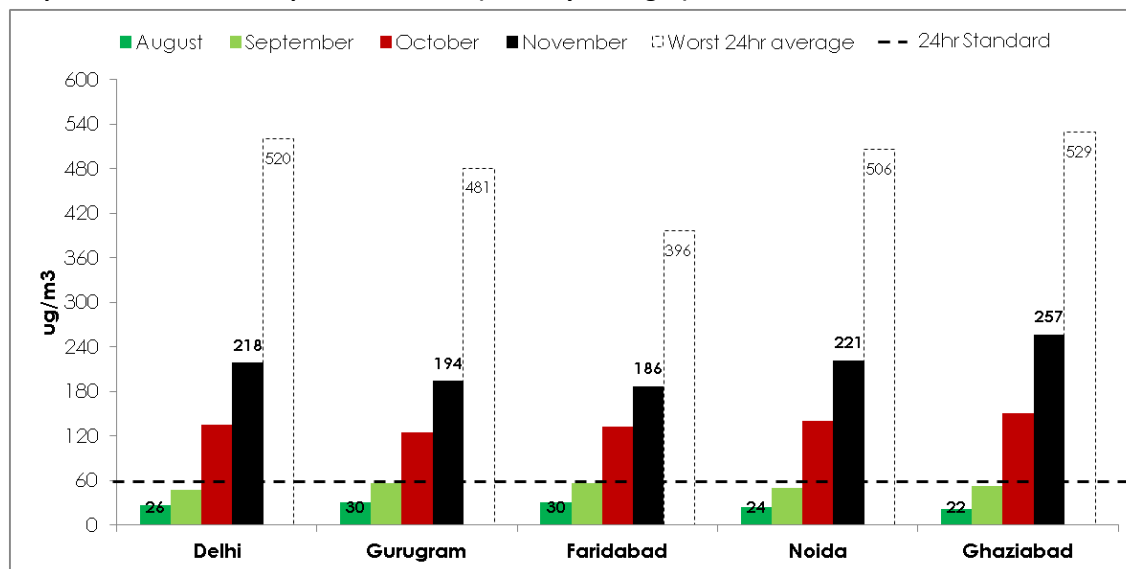
#### Data used in the analysis

The analysis is based on publically available data from various government agencies. Most granular data (15-minute averages) has been sourced from the Central Pollution Control Board's (CPCB) official online portal Central Control Room for Air Quality Management - All India (<https://app.cpcbcr.com/>). This has analysed data recorded by 79 air quality monitoring stations or cent per cent of the current NCR network under the Continuous Ambient Air Quality Monitoring System (CAAQMS) of CPCB. Farm stubble fire data has been sourced from System of Air Quality and Weather Forecasting and Research (SAFAR). Weather data has been sourced from the Palam weather station of Indian Meteorological Department (IMD).

## Key highlights

**Lower average level of PM<sub>2.5</sub> throughout the year due to the lockdown could not prevent the winter spike:** The overall PM<sub>2.5</sub> average this year (until November) has been predictably lower compared to the previous year largely because of the unprecedented economic disruption during the summer lockdown and monsoon. But reopening of the economy coinciding with the onset of the winter trapping pollution made PM<sub>2.5</sub> levels spiral during October and November. From the cleanest weeks of August (the cleanest month on record so far) the levels rose dramatically to one of the dirtiest November in recent years. This rise varied from 9.5 times increase in Delhi to 11 times in Ghaziabad; followed by Noida – 9.2 times, Gurugram by 6.4 times and Faridabad by 6.2 times (See Graph 1: Pollution build-up in 2020 winter (monthly averages)). The transient change of the lockdown phases could not be sustained without the systemic changes needed to control pollution from vehicles, industry, power plants, and waste.

**Graph 1: Pollution build-up in 2020 winter (monthly averages)**

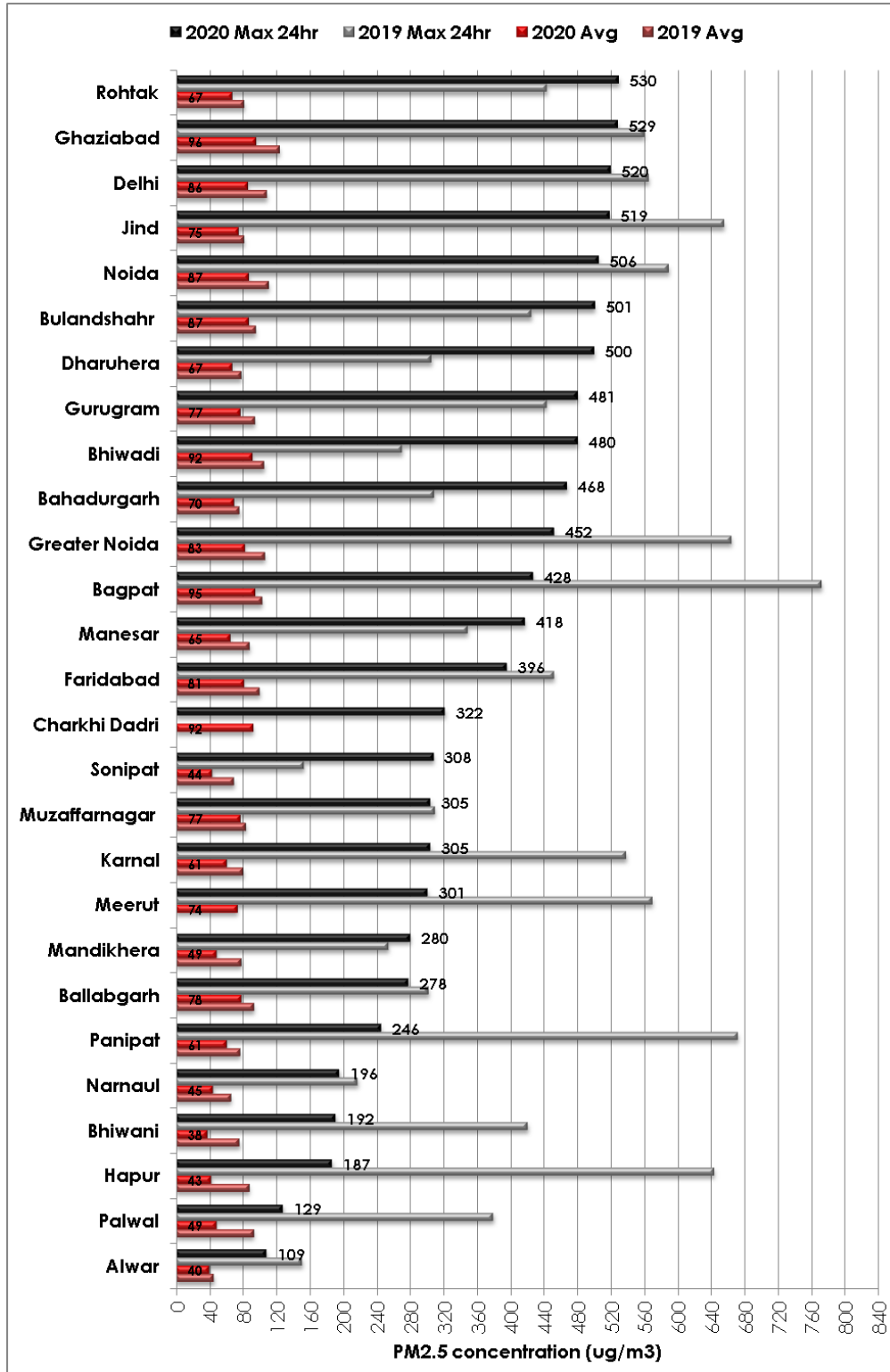


Note: Based on worst 24hr average at the citywide level, not including Diwali day. Average PM<sub>2.5</sub> concentration for a month is based on mean of all CAAQM stations in the city.

Source: CSE analysis of CPCB's realtime air quality data

**Even with comparatively cleaner air round the year other towns in the NCR have recorded spikes as high as those observed in Delhi and big four NCR cities:** CSE has compared the annual averages of the cities and towns of the larger NCR region with that of Delhi and the big four including Gurugram, Faridabad, Noida and Gaziabad. This shows that even with much lower annual average level of PM<sub>2.5</sub> other smaller cities and towns in NCR experience almost same maximum levels during winter when the entire region is in airlock (See Graph 2: Pollution among NCR cities and towns). In fact, even Delhi that has in the recent times witnessed decline in annual average levels year-on-year basis have experienced high pollution build up during winter. This brings out the deadly combination of regional influence with local pollution when meteorology is adverse.

Graph 2: Pollution among NCR cities and towns

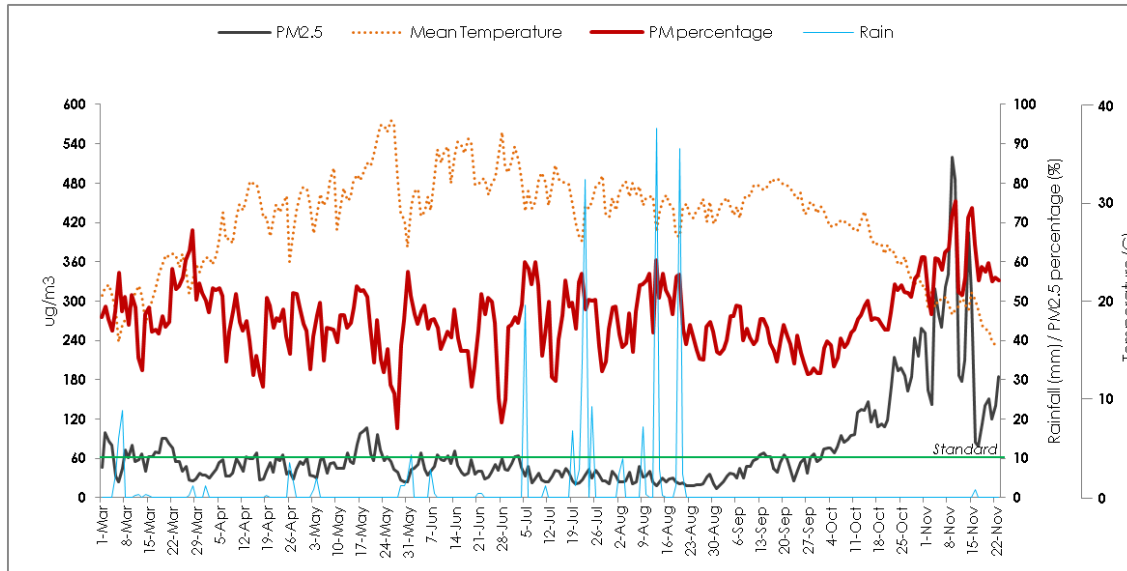


Note: 2020 numbers are based on data up to 30 Nov 2020. Data labels are for 2020 only.

Source: CSE analysis of CPCB's realtime air quality data

**Air quality gets more toxic with the onset of winter - share of tinier PM<sub>2.5</sub> in the PM<sub>10</sub> increases:** The share of tinier and finer particles in the overall coarser PM<sub>10</sub> concentration determines the toxicity of air. Interestingly, during lockdown, when the overall suspended coarser particles had settled down reducing the PM<sub>10</sub> levels, the PM<sub>2.5</sub> had also come down but its share was 47 per cent – higher than its usually noted during summer. But with the onset of winter the percentage share of PM<sub>2.5</sub> in the overall PM<sub>10</sub> rose to over 70 per cent during the smog episodes in early November, and remained high at 50-60 per cent during most of November (See Graph 3: Percentage of PM2.5 in Delhi (1 Mar – 29 Nov, 2020)). The share of PM<sub>2.5</sub> in PM<sub>10</sub> was highest on Diwali reaching over 80 per cent at many locations. Tinier particles are more dangerous as they can penetrate deep inside the lungs and through blood barriers increasing health risk.

**Graph 3: Percentage of PM2.5 in Delhi (1 Mar – 29 Nov, 2020)**



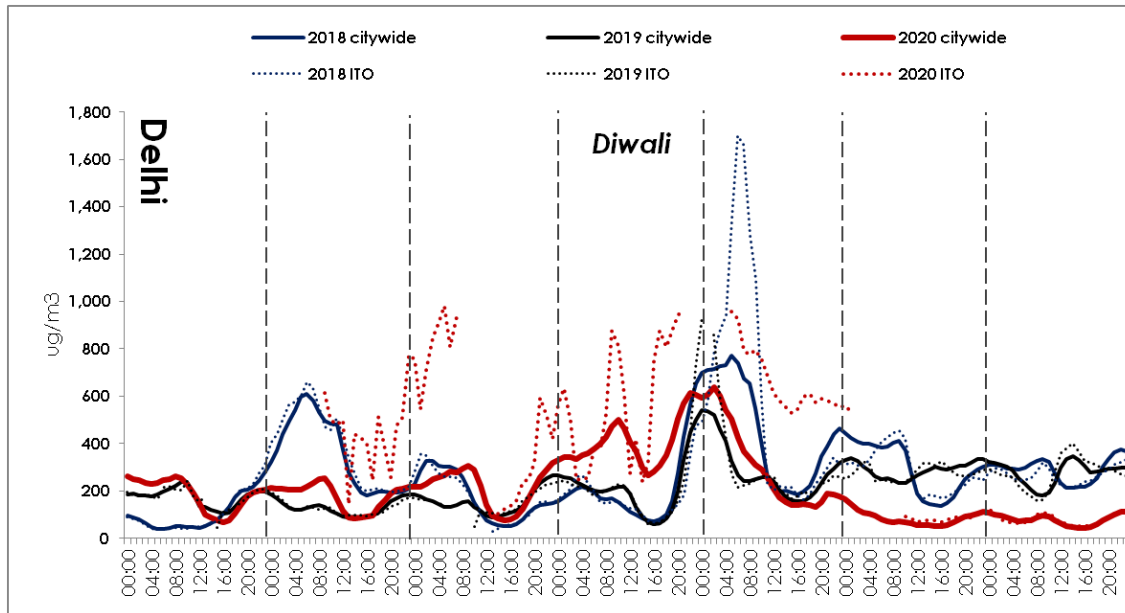
Data: CPCB (PM<sub>10</sub> and PM<sub>2.5</sub>), IMD (Temperature and rainfall)

Source: CSE analysis

**Pattern of smog episode is different this year:** Technically, smog episode is defined for the purpose of emergency action under Graded Response Action Plan when the levels of PM<sub>2.5</sub> remain in severe category for three consecutive days. By that logic the region has experienced one severe smog episode this year (7-10 Nov, 2020) compared to two episodes last year until November (31 Oct-3 Nov, 2019 and 12-15 Nov, 2019). This year the episode preceded Diwali that also much later in November compared to end of October last year. In fact, last year Diwali had catalyzed the first big smog episode of the season.

But this year Diwali pollution from fire crackers combined with smoke from stubble burning and local pollution to start a buildup of severe-plus and extremely hazardous level on day of Diwali itself (14 Nov 2020). But this did not last long to become another smog episode as meteorology along with short rain spell helped to dissipate it quicker. The average PM<sub>2.5</sub> level on Diwali day in Delhi was 404 µg/m<sup>3</sup> and it dropped to 308 µg/m<sup>3</sup> the next day in contrast the trend in the previous years when the levels increased next day. This year pollution was able to disperse faster due to meteorology. But like previous years, there was dramatic change in hourly PM<sub>2.5</sub> concentration between afternoon and night of Diwali due to excessive firecracker busting (See Graph 4: Impact of Diwali on hourly pollution). The change in hourly PM<sub>2.5</sub> concentration between afternoon and night of Diwali was 370 µg/m<sup>3</sup>, down from 480 µg/m<sup>3</sup> in 2019 and 698 µg/m<sup>3</sup> in 2018.

**Graph 4: Impact of Diwali on hourly pollution in Delhi**

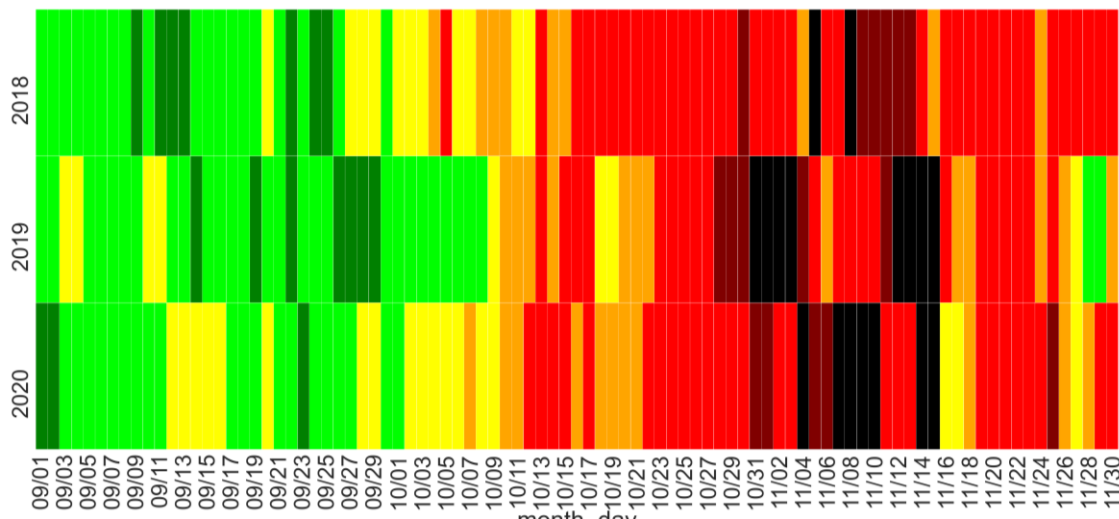


Note: Diwali dates are 7 Nov 2018, 27 Oct 2019, and 14 Nov 2020. Citywide is based on average PM<sub>2.5</sub> concentration of all CAAQM stations operational in the city on a given day. Dotted lines represent a specific CAAQM station of the city to showcase variation in PM<sub>2.5</sub> concentrations among city's numerous CAAQM stations. CPCB portal since 2019 has a cap of 1,000  $\mu\text{g}/\text{m}^3$ , i.e. when the PM<sub>2.5</sub> concentration peaks beyond 999  $\mu\text{g}/\text{m}^3$  (very common on Diwali night) the portal data entry goes blank, therefore the broken line in the graph at Diwali night should be read as concentration beyond 1,000  $\mu\text{g}/\text{m}^3$  instead of being generic missing data.

Source: CSE analysis of CPCB's real time air quality data

**Levels are more volatile recording quicker ups and downs and dispersal aided by overall downward trend in annual trends and meteorology:** The cyclical ups and down of pollution this winter is more volatile – showing quicker rise and fall than pervious winter (See Graph 5: Heatmap of Delhi's daily PM<sub>2.5</sub> level in winter (1 Sept – 30 Nov) of 2018-20). This could also be a reflection of changes in local pollution pattern and overall downward trend while aided by the meteorology.

**Graph 5: Heatmap of Delhi's daily PM<sub>2.5</sub> level in winter (1 Sept – 30 Nov) of 2018-20**



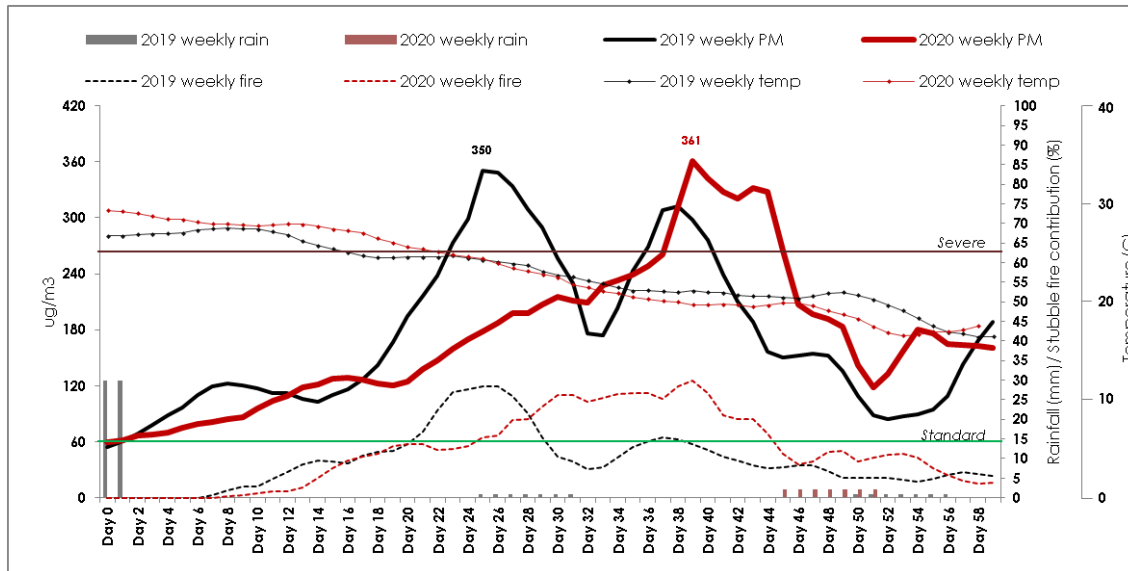
Note: Average PM<sub>2.5</sub> concentration for a day is based on mean of 36 CAAQM stations of Delhi. Days are colored based on AQI categories. Source: CSE analysis of CPCB's realtime air quality data

Firstly, an interesting observation is that there are days this November when air quality improved substantially without the rains but with overall improvement in wind pattern. There are three days during the second half of November in 2020 when the air quality improved to “moderately polluted” AQI category in Delhi. This is same as 2019 but the clean up in 2019 was induced by rains. In 2018, the citywide average never dropped below “poor” AQI category in November. This winter the daily citywide average dropped down even to  $76 \mu\text{g}/\text{m}^3$  on November 27, without any rain to help aid in the cleaning process. In fact, five stations in Delhi met the 24hr standard with Shadipur registering  $41 \mu\text{g}/\text{m}^3$ . Gurugram ( $68 \mu\text{g}/\text{m}^3$ ), Faridabad ( $58 \mu\text{g}/\text{m}^3$ ), and Noida ( $73 \mu\text{g}/\text{m}^3$ ) had even lower citywide average than Delhi, in fact Faridabad met the standard. Ghaziabad had a relatively higher  $84 \mu\text{g}/\text{m}^3$ . This is quite different compared to previous winter.

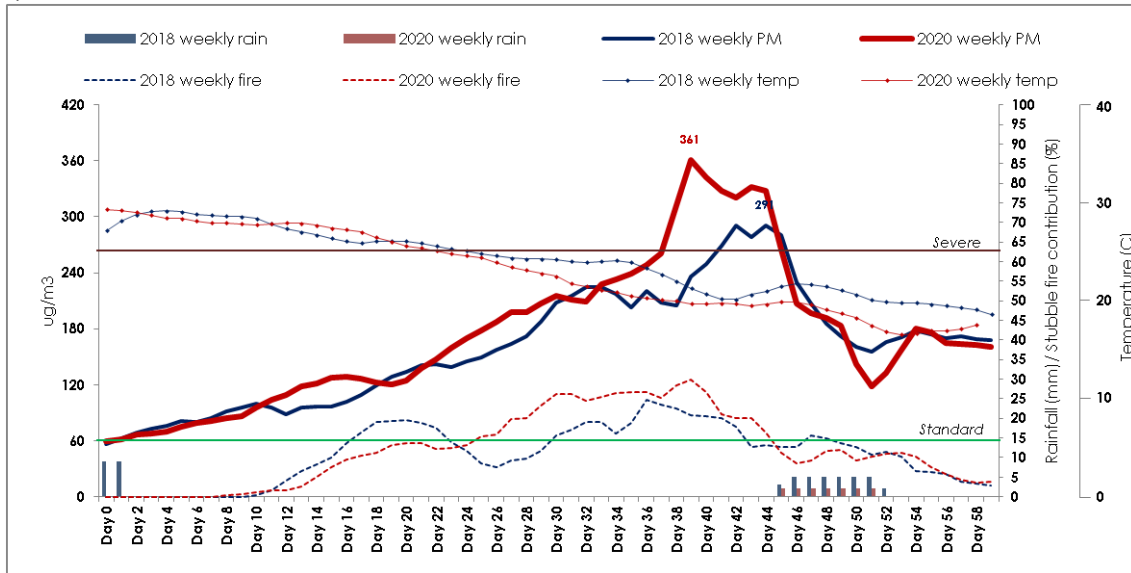
Secondly, this year local pollution across the monitoring locations of Delhi shows wider variation between lower and upper range of pollution. This is in contrast to the range of variation noted last year that was more upper bound. Even on the peak smog day in November this year, the PM<sub>2.5</sub> levels in several stations varied from a lower bound  $108 \mu\text{g}/\text{m}^3$  at NSIT to  $699 \mu\text{g}/\text{m}^3$  at Mundaka. But last year the variation was noted at a higher range – between  $351 \mu\text{g}/\text{m}^3$  at Shadipur to  $725 \mu\text{g}/\text{m}^3$  at Alipur – while the overall level stayed above  $374 \mu\text{g}/\text{m}^3$ . In fact, the standard deviation among the 36 stations of Delhi this November on an average is 60 per cent higher compared to last year across. This indicates somewhat clearing up of local pollution though meteorology plays a part.

Even the rolling weekly average rose slower this year compared to last year (See Graph 6: Rate of increase in PM<sub>2.5</sub> in Delhi a) 2019 vs 2020, b) 2018 vs 2020). It took 37 days to reach the severe category ( $250 \mu\text{g}/\text{m}^3$ ) from the week that last met the standard of  $60 \mu\text{g}/\text{m}^3$  in early October (week ending on 2nd October, 2020). This is considerably slower rise compared to 2019 when it took 23 days. In 2018, it took 40 days but weather was also about  $3^\circ\text{C}$  warmer compared to this November. This November is also among the coldest in the recent years according to IMD.

**Graph 6: Rate of increase in PM<sub>2.5</sub> in Delhi a) 2019 vs 2020, b) 2018 vs 2020**  
a) 2019 vs 2020



b) 2018 vs 2020



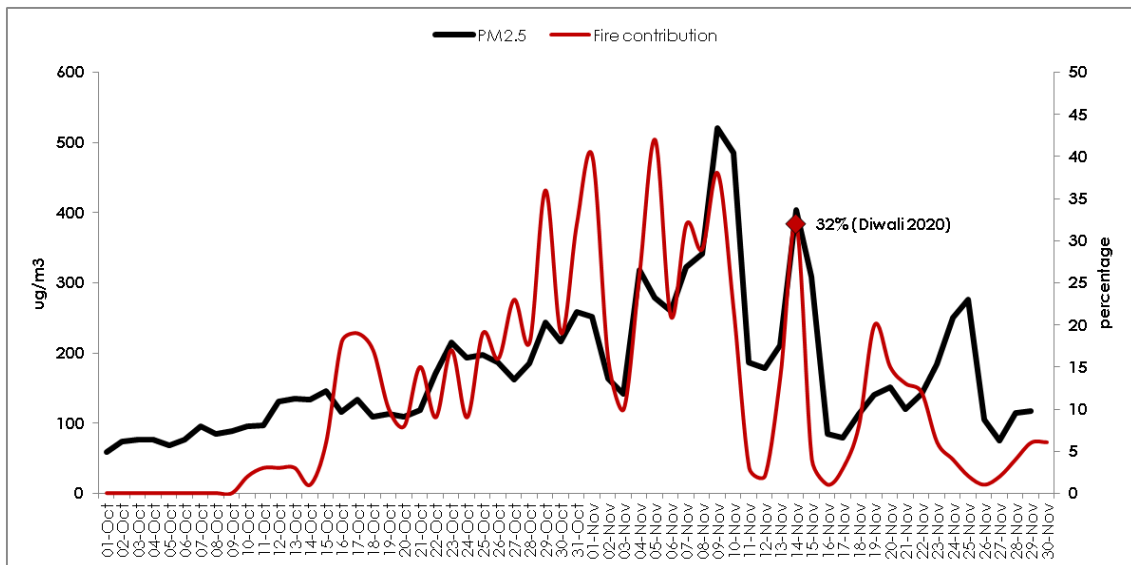
Note: All values are rolling weekly average. Day 0 is the last day when the rolling weekly average was below the standard (60ug/m3). Day 0 for each year is week ending on 30 Sept 2018, 9 Oct 2019, and 2 Oct 2020.

Data: CPCB (PM<sub>2.5</sub>), SAFAR (Stubble fire contribution), IMD (Temperature and rainfall)

Source: CSE analysis

**Contribution of crop burning to the region’s pollution was volatile and higher number of days recorded higher share:** CSE has analysed the data provided by SAFAR on daily percentage contribution of the stubble burning to the PM<sub>2.5</sub> concentration in Delhi-NCR depending on the direction and speed of the wind. This shows that the smoke from crop stubble fire started impacting Delhi more discerningly from 10, October 2020 onwards. This was a week earlier than last year when it started on 16 October, 2019 (See Graph 7: Percentage contribution of stubble fire to Delhi’s PM<sub>2.5</sub> pollution in 2020).

**Graph 7: Percentage contribution of stubble fire to Delhi’s PM<sub>2.5</sub> pollution in 2020**

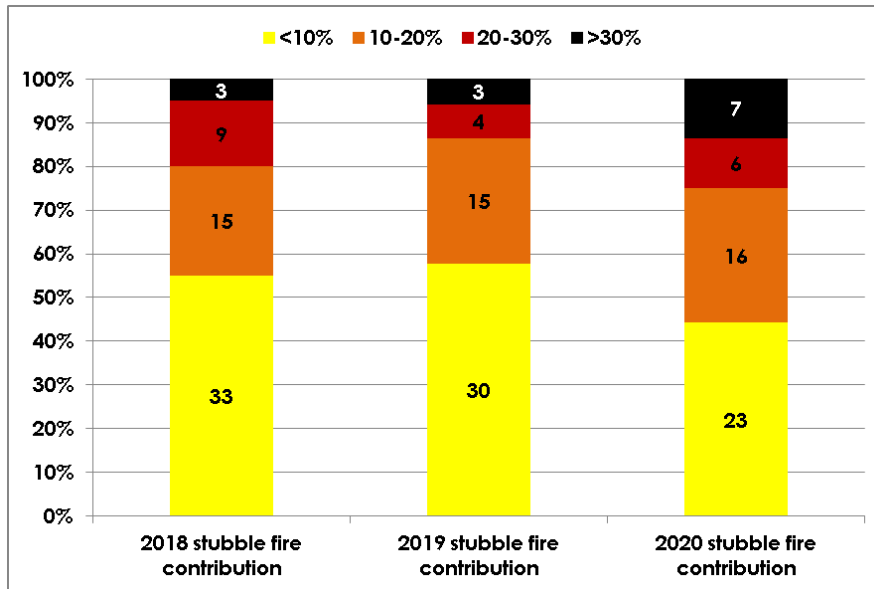


Note: Up till 30 Nov 2020.

Source: CSE analysis of CPCB and SAFAR data

CSE analysed classified days (uptill 30 November) based on daily percentage contribution – less than 10 per cent, 10-20 per cent, 20-30 per cent and above 30 per cent. This shows there were 7 days this year when the contribution of smoke to Delhi's PM<sub>2.5</sub> concentration exceeded 30 per cent in contrast to 3 days in 2019 and 2018 (See Graph 8: Day-wise breakup of stubble fire contribution to Delhi's PM 2.5 pollution). There were 6 days when contribution was between 20-30 per cent, (up from 4 days in 2019) and 16 days of 10-20 per cent contribution (up from 15 days in 2019) and 23 days with less than 10 per cent contribution (down from 30 days in 2019). This year Diwali pollution was also compounded by the heightened contribution of smoke from crop stubble fire as the contribution increased to 32 per cent.

**Graph 8: Day-wise breakup of stubble fire contribution to Delhi's PM 2.5 pollution**



Note: For 10 Oct – 30 Nov of 2018, 2019, and 2020.

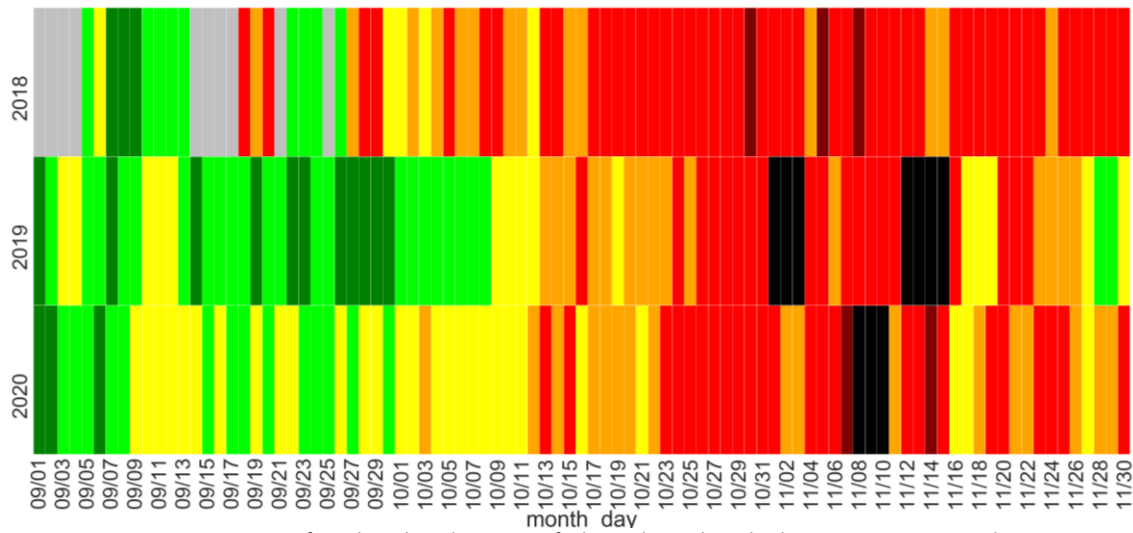
Source: CSE analysis of SAFAR data

How the pollution level will play out during the rest of the winter remains to be seen. But it is clear that the region cannot afford to lose the wins already made and at the same time, raise the level of ambition to drive action across all key sectors of pollution and the entire region. Enforce power plant standards, eliminate coal from the industry, scale up public transport and vehicle restraint measures and manage waste to have a zero waste and zero landfill strategy.



## Additional graphs for NCR cities

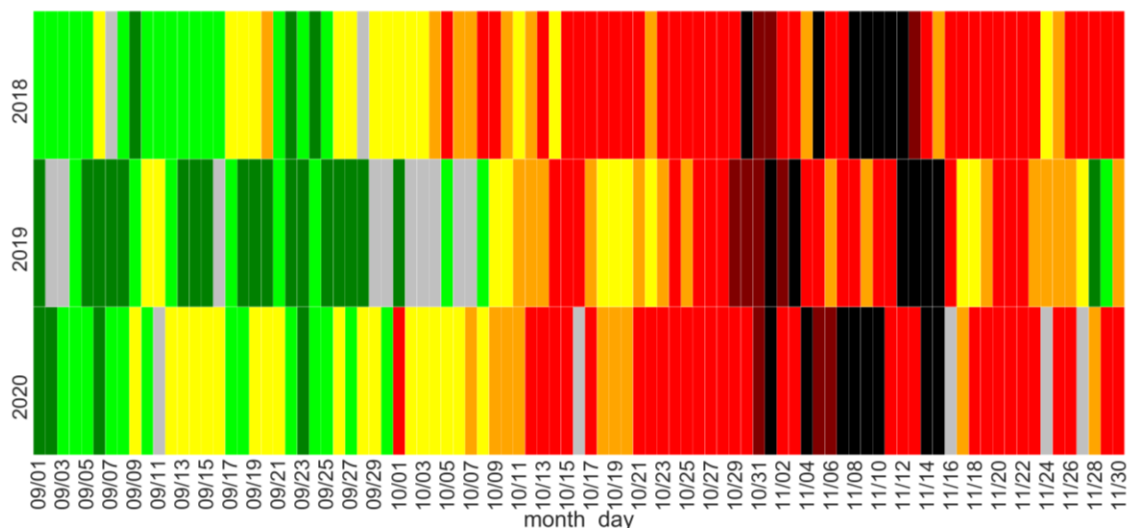
**Graph 5.1: Heatmap of Gurugram's daily PM<sub>2.5</sub> level in winter (1 Sept – 30 Nov) of 2018-20**



Note: Average PM<sub>2.5</sub> concentration for a day is based on mean of Vikas Sadan and Gwal Pahari CAAQM stations in the city. Days are colored based on AQI categories.

Source: CSE analysis of CPCB's realtime air quality data

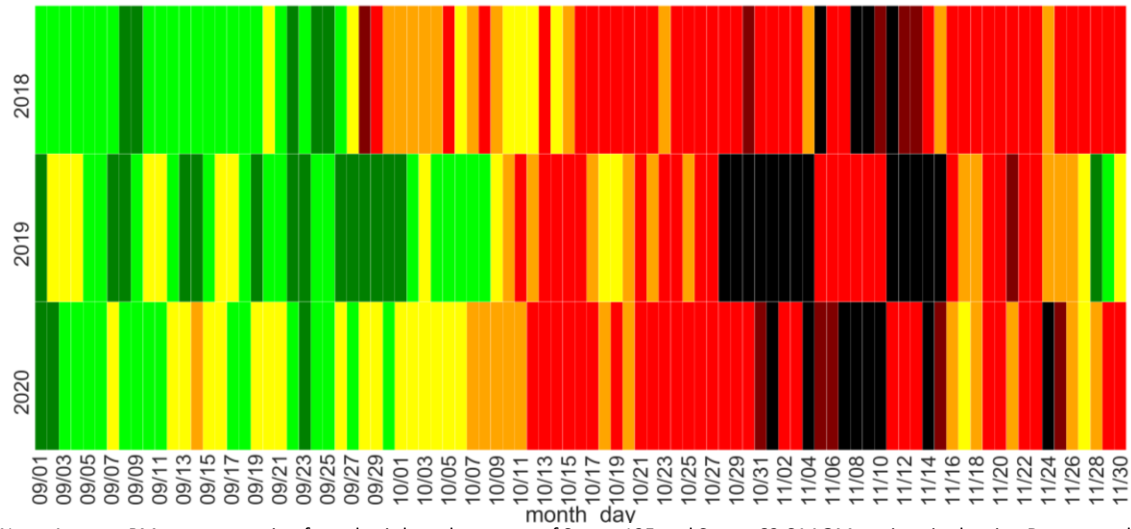
**Graph 5.2: Heatmap of Faridabad's daily PM<sub>2.5</sub> level in winter (1 Sept – 30 Nov) of 2018-20**



Note: Average PM<sub>2.5</sub> concentration for a day is based on Faridabad Sector 16A CAAQM station in the city. Days are colored based on AQI categories.

Source: CSE analysis of CPCB's realtime air quality data

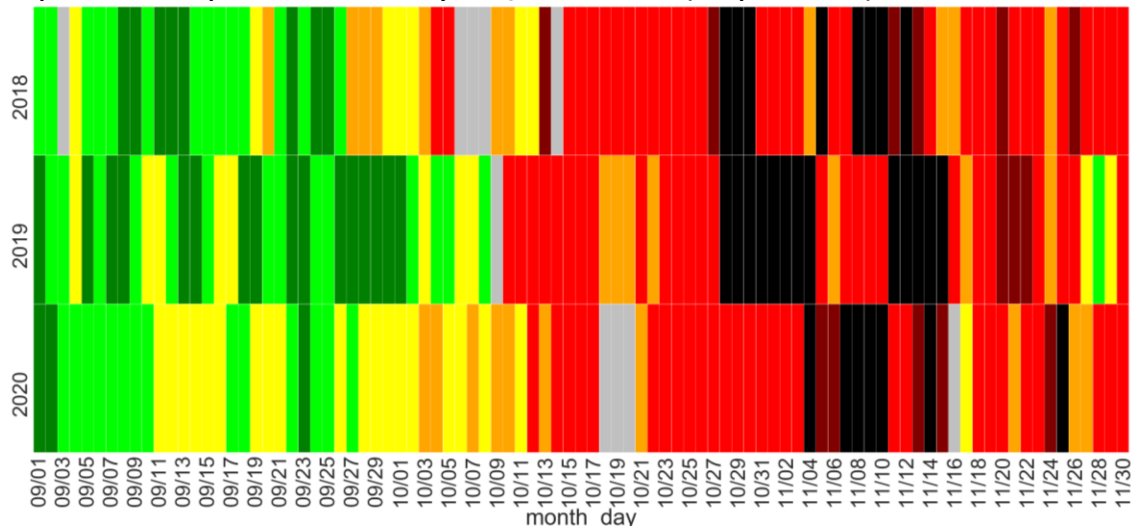
**Graph 5.3: Heatmap of Noida’s daily PM<sub>2.5</sub> level in winter (1 Sept – 30 Nov) of 2018-20**



Note: Average PM<sub>2.5</sub> concentration for a day is based on mean of Sector 125 and Sector 62 CAAQM stations in the city. Days are colored based on AQI categories.

Source: CSE analysis of CPCB’s realtime air quality data

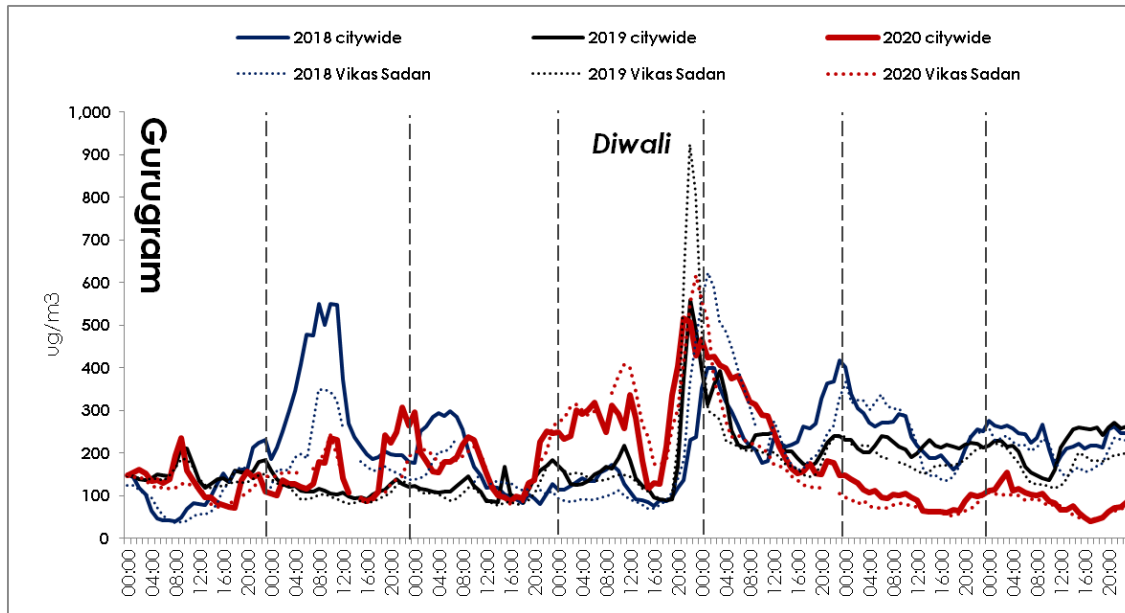
**Graph 5.4: Heatmap of Ghaziabad’s daily PM<sub>2.5</sub> level in winter (1 Sept – 30 Nov) of 2018-20**



Note: Average PM<sub>2.5</sub> concentration for a day is based on Varundhara CAAQM station in the city. Days are colored based on AQI categories.

Source: CSE analysis of CPCB’s realtime air quality data

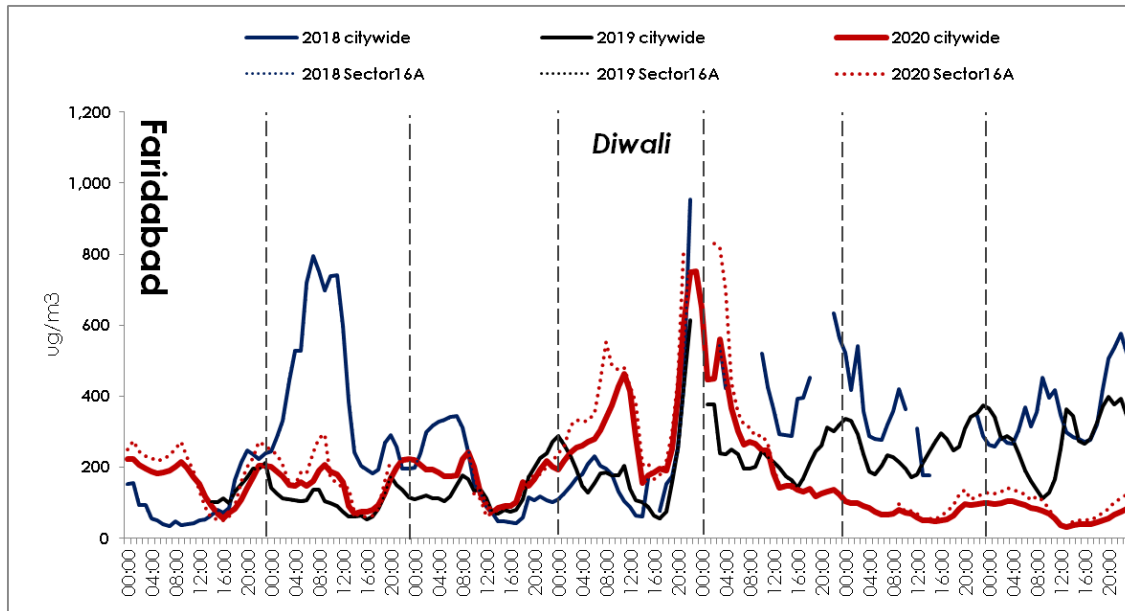
**Graph 4.1: Impact of Diwali on hourly pollution in Gurugram**



Note: Diwali dates are 7 Nov 2018, 27 Oct 2019, and 14 Nov 2020. Citywide is based on average PM<sub>2.5</sub> concentration of all CAAQM stations operational in the city on a given day. Dotted lines represent a specific CAAQM station of the city to showcase variation in PM<sub>2.5</sub> concentrations among city's numerous CAAQM stations. CPCB portal has a cap of 1,000  $\mu\text{g}/\text{m}^3$ , i.e. when the PM<sub>2.5</sub> concentration peaks beyond 999  $\mu\text{g}/\text{m}^3$  (very common on Diwali night) the portal data entry goes blank, therefore the broken line in the graph at Diwali night should be read as concentration beyond 1,000  $\mu\text{g}/\text{m}^3$  instead of being generic missing data.

Source: CSE analysis of CPCB's real time air quality data

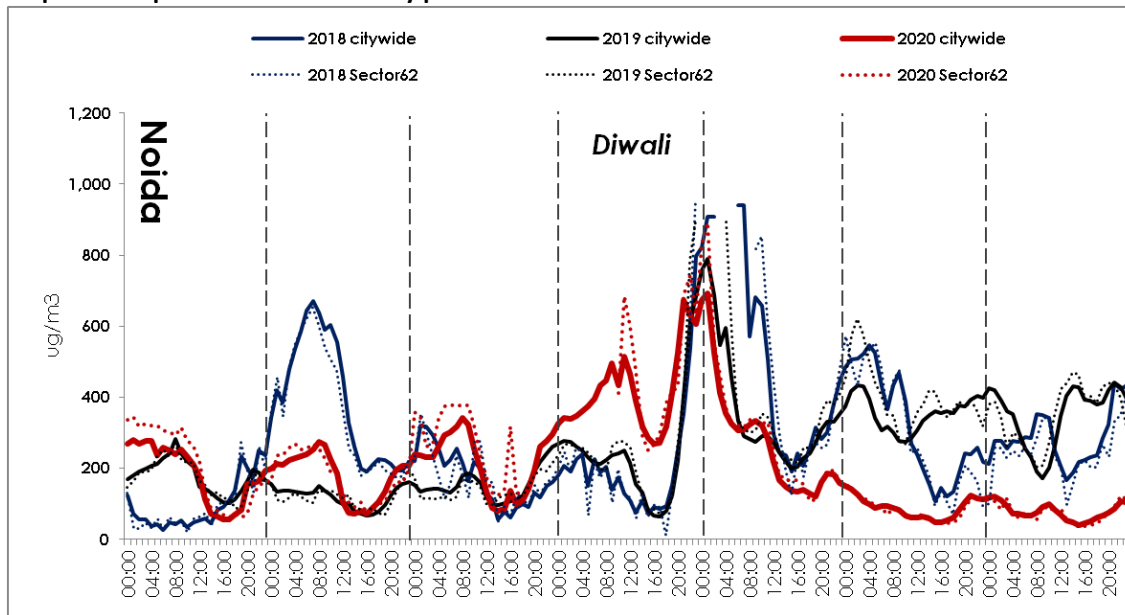
**Graph 4.2: Impact of Diwali on hourly pollution in Faridabad**



Note: Diwali dates are 7 Nov 2018, 27 Oct 2019, and 14 Nov 2020. Citywide is based on average PM<sub>2.5</sub> concentration of all CAAQM stations operational in the city on a given day. Dotted lines represent a specific CAAQM station of the city to showcase variation in PM<sub>2.5</sub> concentrations among city's numerous CAAQM stations. CPCB portal has a cap of 1,000  $\mu\text{g}/\text{m}^3$ , i.e. when the PM<sub>2.5</sub> concentration peaks beyond 999  $\mu\text{g}/\text{m}^3$  (very common on Diwali night) the portal data entry goes blank, therefore the broken line in the graph at Diwali night should be read as concentration beyond 1,000  $\mu\text{g}/\text{m}^3$  instead of being generic missing data.

Source: CSE analysis of CPCB's real time air quality data

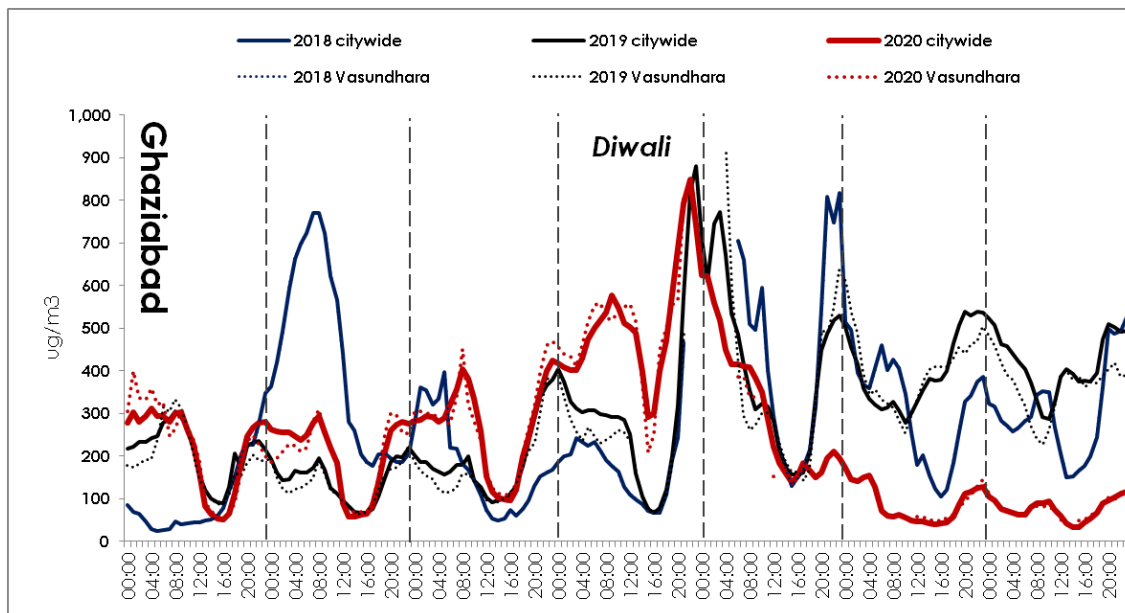
**Graph 4.3: Impact of Diwali on hourly pollution in Noida**



Note: Diwali dates are 7 Nov 2018, 27 Oct 2019, and 14 Nov 2020. Citywide is based on average PM<sub>2.5</sub> concentration of all CAAQM stations operational in the city on a given day. Dotted lines represent a specific CAAQM station of the city to showcase variation in PM<sub>2.5</sub> concentrations among city's numerous CAAQM stations. CPCB portal has a cap of 1,000  $\mu\text{g}/\text{m}^3$ , i.e. when the PM<sub>2.5</sub> concentration peaks beyond 999  $\mu\text{g}/\text{m}^3$  (very common on Diwali night) the portal data entry goes blank, therefore the broken line in the graph at Diwali night should be read as concentration beyond 1,000  $\mu\text{g}/\text{m}^3$  instead of being generic missing data.

Source: CSE analysis of CPCB's real time air quality data

**Graph 4.4: Impact of Diwali on hourly pollution in Ghaziabad**



Note: Diwali dates are 7 Nov 2018, 27 Oct 2019, and 14 Nov 2020. Citywide is based on average PM<sub>2.5</sub> concentration of all CAAQM stations operational in the city on a given day. Dotted lines represent a specific CAAQM station of the city to showcase variation in PM<sub>2.5</sub> concentrations among city's numerous CAAQM stations. CPCB portal has a cap of 1,000  $\mu\text{g}/\text{m}^3$ , i.e. when the PM<sub>2.5</sub> concentration peaks beyond 999  $\mu\text{g}/\text{m}^3$  (very common on Diwali night) the portal data entry goes blank, therefore the broken line in the graph at Diwali night should be read as concentration beyond 1,000  $\mu\text{g}/\text{m}^3$  instead of being generic missing data.

Source: CSE analysis of CPCB's real time air quality data

## List of CAAQM stations in Delhi-NCR

	State/UT	City	Name
1	Delhi	Delhi	Alipur, Delhi
2	Delhi	Delhi	Shadipur, Delhi
3	Delhi	Delhi	Dilshad Garden, Delhi
4	Delhi	Delhi	NSIT Dwarka, Delhi
5	Delhi	Delhi	DTU, Delhi
6	Delhi	Delhi	ITO, Delhi
7	Delhi	Delhi	Siri fort, Delhi
8	Delhi	Delhi	Mandir Marg, Delhi
9	Delhi	Delhi	Anand Vihar, Delhi
10	Delhi	Delhi	R K Puram, Delhi
11	Delhi	Delhi	Punjabi Bagh, Delhi
12	Delhi	Delhi	Aya Nagar, Delhi
13	Delhi	Delhi	Lodhi Road, Delhi
14	Delhi	Delhi	North Campus, Delhi University, Delhi
15	Delhi	Delhi	Burari Crossing, Delhi
16	Delhi	Delhi	CRRI Mathura Road, Delhi
17	Delhi	Delhi	Pusa, Delhi
18	Delhi	Delhi	IGI Airport, Delhi
19	Delhi	Delhi	East Arjun Nagar, Delhi
20	Delhi	Delhi	Ashok Vihar, Delhi
21	Delhi	Delhi	Jawaharlal Nehru Stadium, Delhi
22	Delhi	Delhi	Nehru Nagar, Delhi
23	Delhi	Delhi	Dwarka-Sector 8, Delhi
24	Delhi	Delhi	Dr. Karni Singh Shooting Range, Delhi
25	Delhi	Delhi	Patparganj, Delhi
26	Delhi	Delhi	Sonia Vihar, Delhi
27	Delhi	Delhi	Jahangirpuri, Delhi
28	Delhi	Delhi	Rohini, Delhi
29	Delhi	Delhi	Najafgarh, Delhi
30	Delhi	Delhi	Vivek Vihar, Delhi
31	Delhi	Delhi	Major Dhyan Chand National Stadium, Delhi
32	Delhi	Delhi	Narela, Delhi
33	Delhi	Delhi	Okhla Phase-2, Delhi
34	Delhi	Delhi	Wazirpur, Delhi
35	Delhi	Delhi	Bawana, Delhi
36	Delhi	Delhi	Sri Aurobindo Marg, Delhi
37	Delhi	Delhi	Pusa, Delhi
38	Delhi	Delhi	Mundka, Delhi
39	Haryana	Bahadurgarh	Bahadurgarh
40	Haryana	Ballabgarh	Ballabgarh
41	Haryana	Bhiwani	Bhiwani
42	Haryana	Charkhi Dadri	Charkhi Dadri
43	Haryana	Dharuhera	Dharuhera
44	Haryana	Faridabad	Sector 16A, Faridabad
45	Haryana	Faridabad	New Industrial Town, Faridabad
46	Haryana	Faridabad	Sector 11, Faridabad
47	Haryana	Faridabad	Sector 30, Faridabad
48	Haryana	Gurgaon	Vikas Sadan, Gurugram
49	Haryana	Gurgaon	NISE Gwal Pahari, Gurugram
50	Haryana	Gurgaon	Sector 51, Gurugram
51	Haryana	Gurgaon	Teri Gram, Gurugram
52	Haryana	Jind	Jind
53	Haryana	Karnal	Karnal
54	Haryana	Mandikhera	Mandikhera
55	Haryana	Manesar	Manesar
56	Haryana	Narnaul	Narnaul
57	Haryana	Palwal	Palwal
58	Haryana	Panipat	Panipat
59	Haryana	Rohtak	Rohtak

60	Haryana	Sonipat	Sonipat
61	Rajasthan	Alwar	Alwar
62	Rajasthan	Bhiwadi	Bhiwadi
63	Uttar Pradesh	Baghpat	Baghpat
64	Uttar Pradesh	Bulandshahr	Bulandshahr
65	Uttar Pradesh	Ghaziabad	Vasundhara, Ghaziabad
66	Uttar Pradesh	Ghaziabad	Indirapuram, Ghaziabad
67	Uttar Pradesh	Ghaziabad	Sanjay Nagar, Ghaziabad
68	Uttar Pradesh	Greater Noida	Knowledge Park III, Greater Noida
69	Uttar Pradesh	Greater Noida	Knowledge Park V, Greater Noida
70	Uttar Pradesh	Hapur	Hapur
71	Uttar Pradesh	Ghaziabad	Loni, Ghaziabad
72	Uttar Pradesh	Meerut	Jai Bhim Nagar, Meerut
73	Uttar Pradesh	Meerut	Ganga Nagar, Meerut
74	Uttar Pradesh	Meerut	Pallavpuram Phase 2, Meerut
75	Uttar Pradesh	Muzaffarnagar	Muzaffarnagar
76	Uttar Pradesh	Noida	Sector 62, Noida
77	Uttar Pradesh	Noida	Sector 125, Noida
78	Uttar Pradesh	Noida	Sector 1, Noida
79	Uttar Pradesh	Noida	Sector 116, Noida