

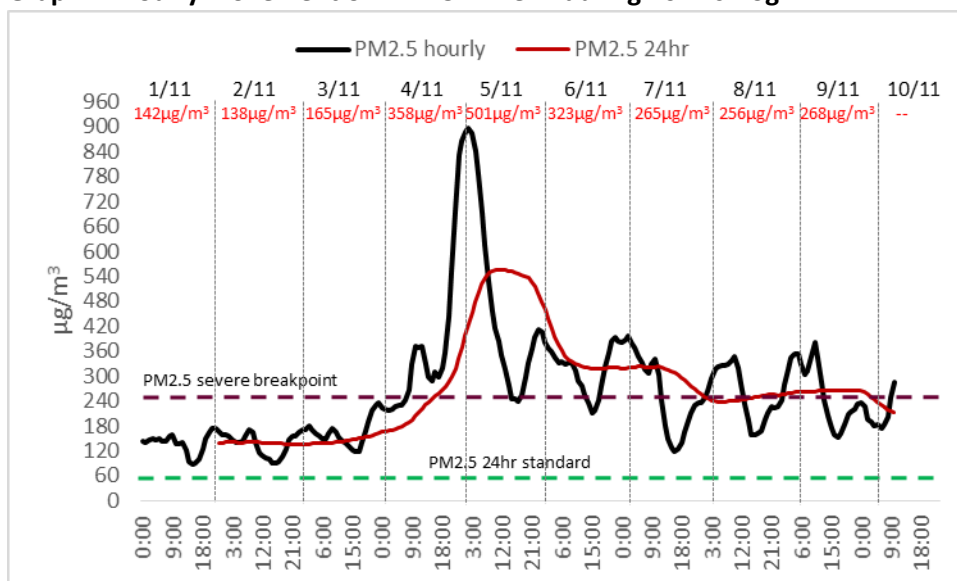
First smog episode of the season: Decoding this year's Delhi smog

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Season's first smog: PM_{2.5} concentration in Delhi skyrocketed beyond 250 ug/m³ (breakpoint for severe AQI category) on Nov 4th and is still hovering over it seven days on. It hit its peak concentration of 501 ug/m³ on 5th November then gradually receded to 256 ug/m³ on 8th November. Since it has started to climb again and stood at 264 ug/m³ on 9th November. Hourly levels are again rising on 10th of November (checked up to 10AM) and if weather conditions don't improve even 10th November might end-up with 24-hr average higher than 250 ug/m³. It should be noted that CSE assessment is based on monitoring in Delhi alone and daily average is considered from midnight to midnight, which is different from CPCB's methodology. CPCB for its trend counter used for GRAP uses average of all stations in Delhi and NCR towns, while CPCB AQI bulletin uses 4PM to 4PM as measure of its daily value.

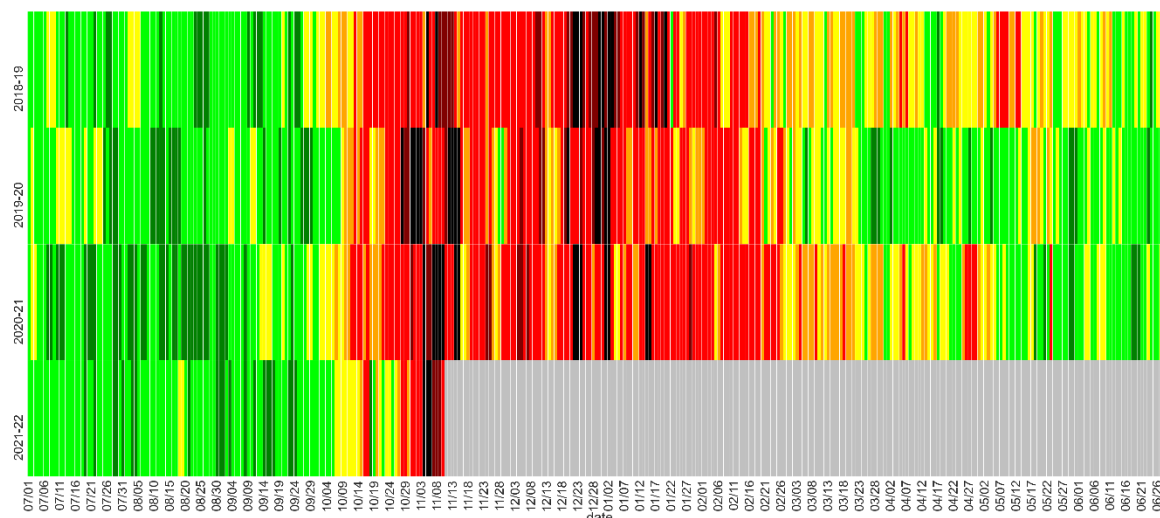
Graph 1: Hourly movement of PM_{2.5} in Delhi during 2021 smog



Note: Average PM_{2.5} concentration is based on mean of daily values recorded at 39 CAAQM stations in the city that have adequate data. 24-hr average is based on midnight to midnight.

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

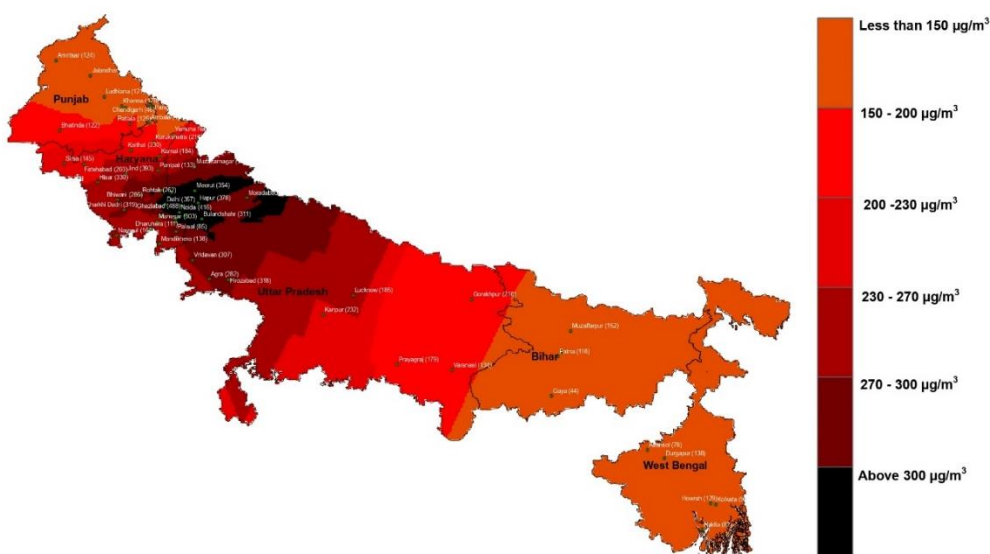
Compared to the first smog episode of previous four years, current smog has matched the duration of first smog of 2018 and 2020 season both lasted 6 days. If the conditions don't improve it might over take 2019 smog lasted 8 days. Average intensity of the smog this year so far was 329 ug/m³ per day, which is lower than 2020 smog (by 7 per cent) and 2019 smog (by 3 per cent). It is more intense than 2018 smog (about 9 per cent). Lingering on of this year's smog for longer duration despite relatively windier local conditions might be due to lack of pollution control measures in the city this year.

Graph 2: PM_{2.5} heatmap of Delhi (2018-21)

Note: Average PM_{2.5} concentration is based on mean of daily values recorded at 36 CAAQM stations in the city that have adequate data for all four years. Cell colour is based on the official colour-scheme of AQI sub-categories.

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

Extent of the smog: PM_{2.5} levels increased across all IGP cities on Diwali night as per the expectation but lingering of it for multiple days to develop into a smog episode only happened in cities Delhi-NCR and western UP. Hisar and Jind marks the northern extent of the smog while southern extent is Agra and Firozabad. Epicenter of this was Ghaziabad and Noida where daily levels reached 635 $\mu\text{g}/\text{m}^3$ and 601 $\mu\text{g}/\text{m}^3$ respectively. Smog in the rural districts of Bhiwani, Charki Dadri, Hisar and Jind in western Haryana exhibits distinct behavior from the urban centers east of them. Their peak happened on the day of Diwali instead of the day after Diwali and lesser daily fluctuation in concentrations. More research is needed to characterize smog in rural regions.

Map 1: Smog map of IGP (4-7 November, 2021)

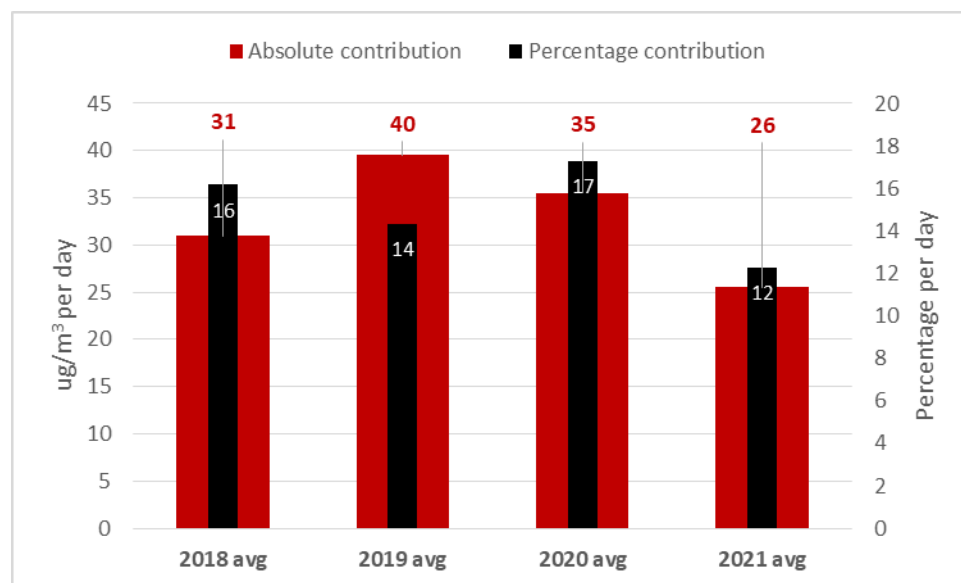
Note: Average PM_{2.5} concentration is based on mean of daily values recorded at CAAQM stations in the city that have adequate data. Values are based on average daily concentration of four days 4-7 November, 2021.

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

Farm stubble fire smoke is lower this season: On an average contribution of smoke to Delhi's daily PM_{2.5} during middle of October to November 8th has been the lowest in last 4 years. So far it has recorded on an average 12 per cent per day in contrast to 17 per cent per day in 2020, 14 per cent per day in 2019, and 16 per cent per day in 2018 (as reported by SAFAR). If converted to absolute concentration then per day contribution of smoke stood at 26 ug/m³ this year so far compared to 35 ug/m³ in 2020, 40 ug/m³ in 2019, and 31 ug/m³ in 2018.

However, peak contribution of smoke to Delhi's PM level was recorded on 7th November when it hit 48 per cent. This the second highest daily contribution percentage recorded since such estimation was started by SAFAR in 2018. The highest single day contribution percentage has been 58 per cent recorded on 5th November 2018. But this unusually high percentage on 7th November, 2021 didn't spike Delhi's PM_{2.5} levels as on that day PM_{2.5} levels came down to 265 ug/m³ from their 5th November 2021 peak of 501 ug/m³.

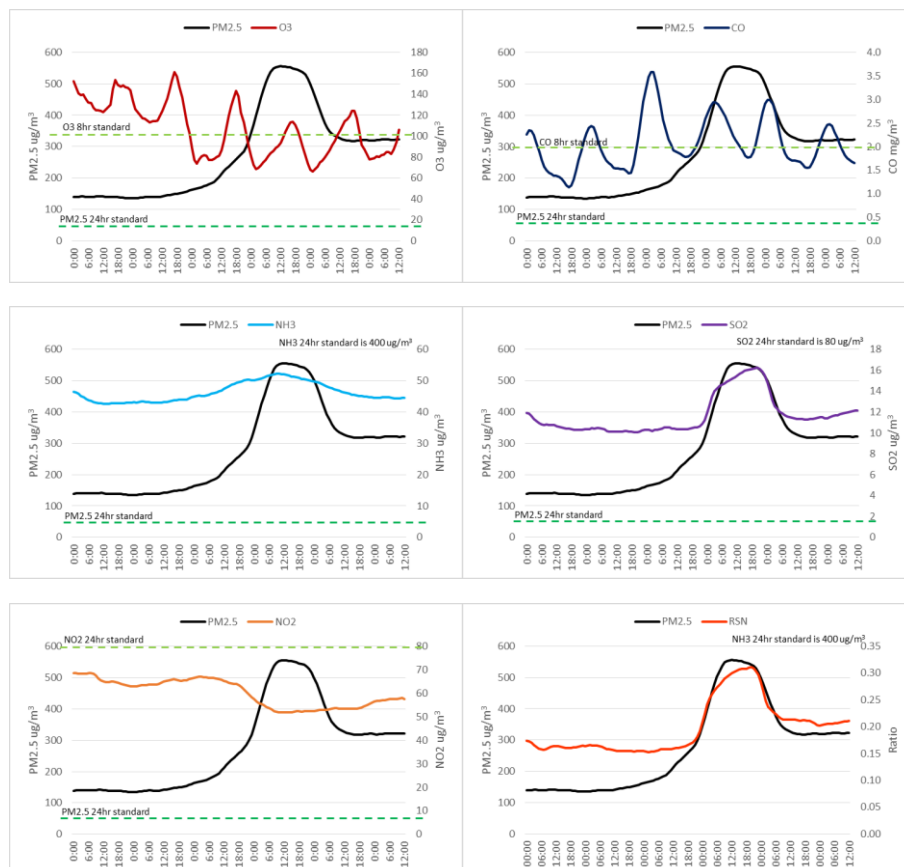
Graph 3: Average contribution from farm stubble fire smoke to Delhi's air



Source: CSE analysis of CPCB's real time air quality data and SAFAR data on farm fire contribution

Other toxic gases during smog episode: During this smog episode ozone levels have continued to breach standard at ozone hotspots in the city even during the peak smog episodes. Levels are even higher pre and post peak smog day. CO is also found to be exceeding the standard through the smog episode. SO₂ levels mimic the trend of PM_{2.5} but it doesn't breach the standard. NO₂ bucks the trend and is seen to drop in concentrations when PM_{2.5} peaks.

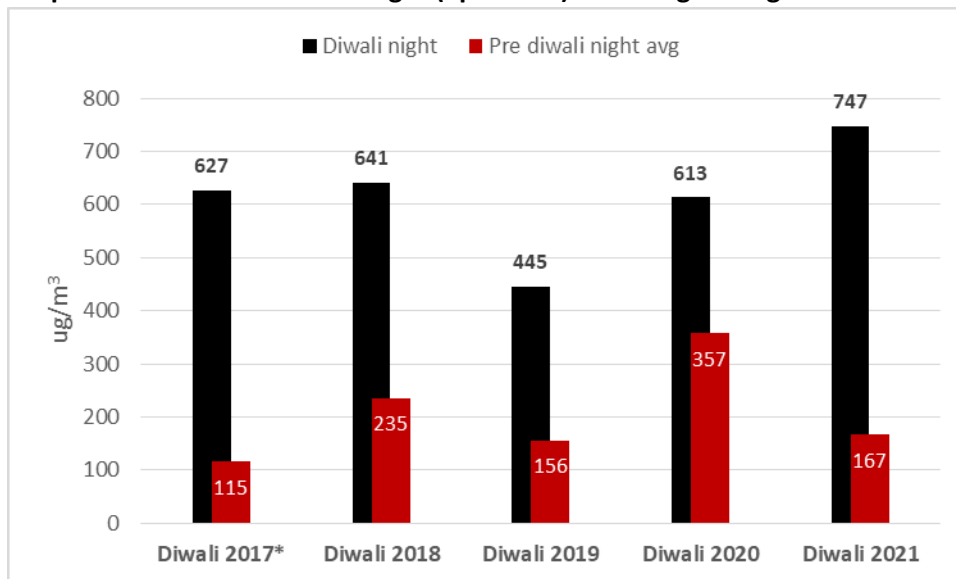
Graph 4: Relation of PM_{2.5} level with other pollutants during smog episode (1-8 Nov, 2021)



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

Delhi Worst Diwali night in last 5 year: PM_{2.5} concentration at the Diwali night (8pm to 8am) was the worst in last five years. The 12-hr night average stood at 747 ug/m³, 22 per cent higher than 2020 Diwali night. The levels on Diwali night were 4.5 times the average night-time levels recorded in the week preceding Diwali. Please note that this Diwali night value is an undercount as CPCB caps PM_{2.5} data at 1,000 ug/m³. It is noted that hourly concentrations can go beyond 1,000 ug/m³. This year 26 of 38 operational monitoring stations hit the 1,000 ug/m³ mark. In 2020, 23 out of 38 station had hit the 1000 ug/m³ mark while in 2019 the number stood at 22 stations. Data on DPCC website show that hourly concentration went as high as 1,984 ug/m³ at Okhla Phase 2 and 1,957 ug/m³ at Ashok Vihar. The 12-hr night average for 24 DPCC stations stood at 824 ug/m³ using the uncapped data. This is 9 per cent higher than average computed from CPCB data for same 24 stations.

Graph 5: PM_{2.5} levels Diwali-night (8pm-8am) vs average of nights in the week preceding Diwali

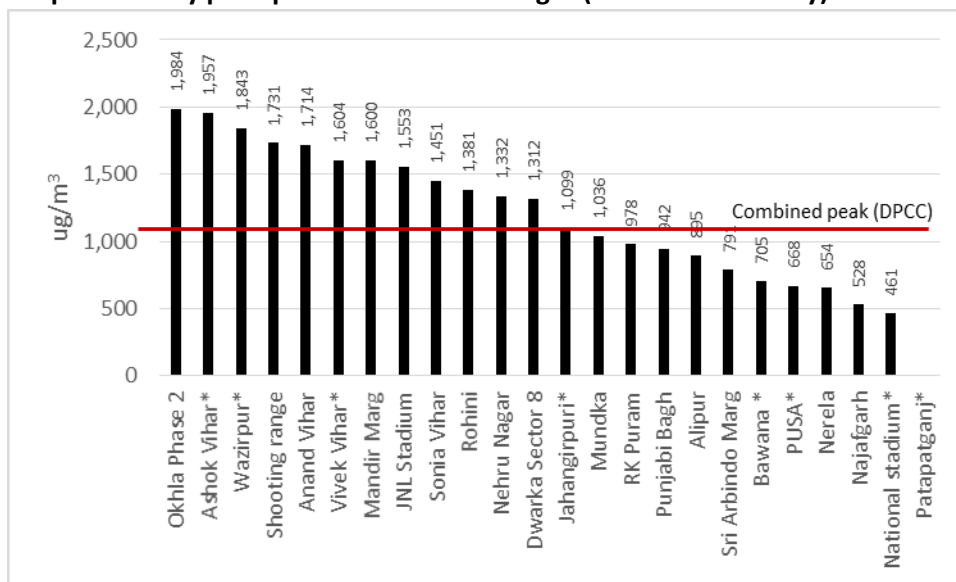


Note: Average concentration is based on mean of 12hr values recorded at 38 CAAQM stations in the city that have adequate data for all four years. Nighttime is 8pm to 8am. Pre-diwali night average is mean of nighttime levels of seven preceding nights.

* Based on lesser number of stations

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

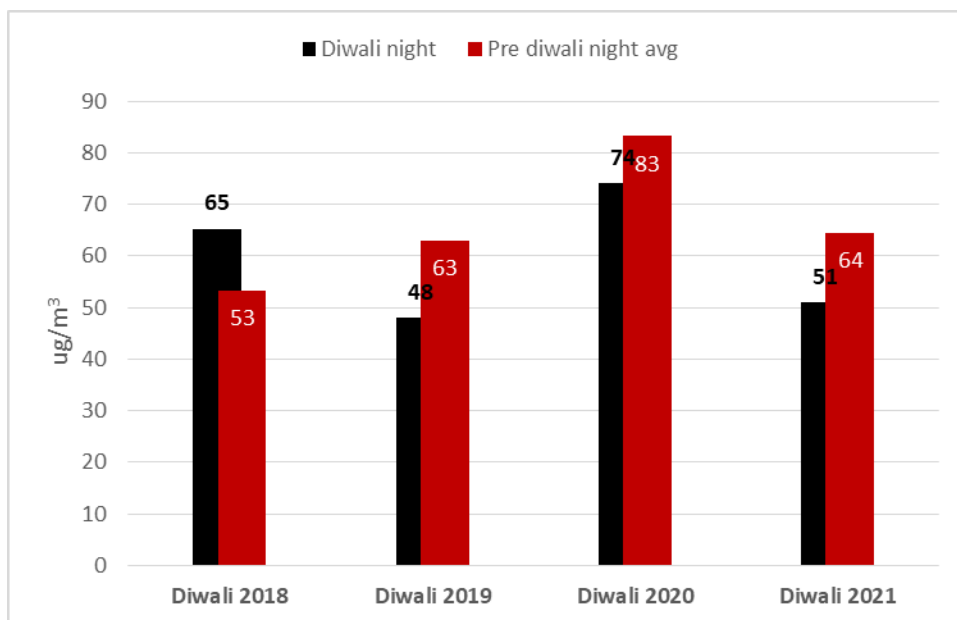
Graph 6: Hourly peak pollution on Diwali-night (DPCC stations only)



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

Diwali traffic shows up as elevated NO₂ levels: Diwali night this year had lower NO₂ levels compared 2020 Diwali night. NO₂ level in last three years have been lower on Diwali night compared to nights preceding it, which is indicative of congestion and high traffic conditions in the city leading to the festival night. And also reflective of less traffic on Diwali night itself. DTU had highest NO₂ levels in the city with night-time average of 154 ug/m³. Dwarka Sector 8 and Anand Vihar with 107 ug/m³ and 103 ug/m³ were the other NO₂ hotspot on Diwali night. Rohini with just 2 ug/m³ of NO₂ was the least affected area in the city followed by Nerala (5 ug/m³) and JNL Stadium (10 ug/m³).

Graph 7: Diwali-night (8pm-8am) NO₂ levels vs average NO₂ level at nights in the week preceding Diwali



Note: Average concentration is based on mean of 12hr values recorded at 38 CAAQM stations in the city that have adequate data for all four years. Nighttime is 8pm to 8am. Pre-diwali night average is mean of nighttime levels of seven preceding nights.

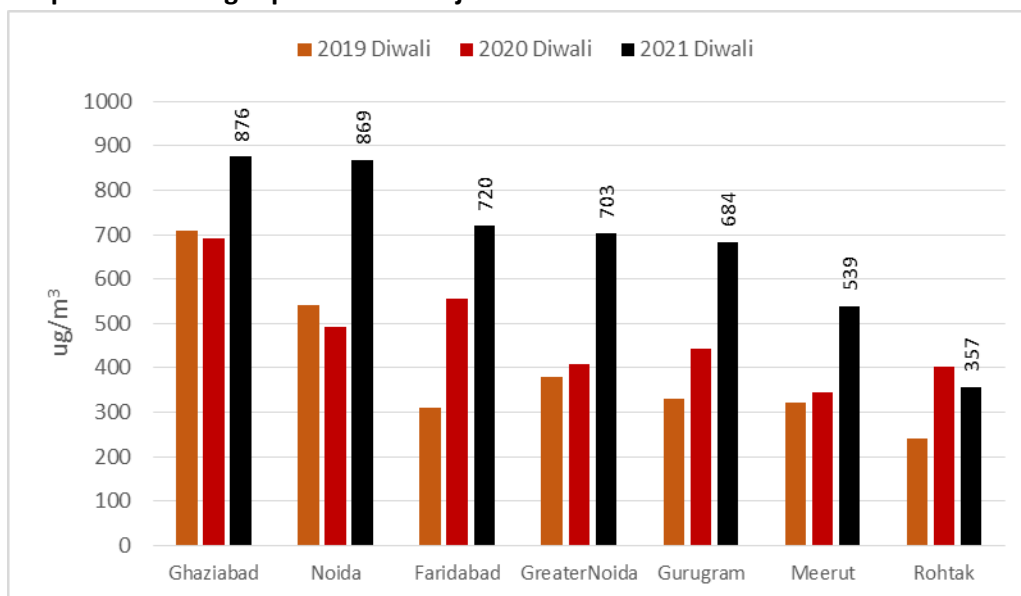
* Based on lesser number of stations

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

Additional information

This year Diwali night in most NCR cities was dirtiest in last three years: Ghaziabad had the most polluted Diwali night among NCR cities and towns. With the night average of 876 ug/m³ it was 26 per cent higher than 2020 Diwali night and 23 per cent higher than 2019 Diwali night. Noida was only marginally better at night average of 869 ug/m³ with 77 per cent jump from 2020 level. Faridabad at 720 ug/m³, Greater Noida at 703 ug/m³, Gurugram at 684 ug/m³ and Meerut at 539 ug/m³ were not any better. Rohtak was only major NCR city which saw lower pollution level this diwali compared to previous year, its 357 ug/m³ was 11 per cent lower than 2020 Diwali night level.

Graph 8: Diwali night pollution in major NCR cities.



Note: Average concentration is based on mean of 12hr values recorded at CAAQM stations in the city that have adequate data for all three years. Nighttime is 8pm to 8am.

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

Table 1: Smog levels in the cities of IGP (4-7 November, 2021)

	Smog intensity (ug/m3 per day)		Smog intensity (ug/m3 per day)
Ghaziabad	488	Lucknow	185
Noida	416	Karnal	184
Jind	393	Prayagraj	179
Hapur	378	Narnaul	164
Gurugram	371	YamunaNagar	155
Bagpat	370	Ambala	153
Delhi	357	Muzaffarpur	152
Meerut	354	Sirsa	145
Greater Noida	341	Mandi Gobindgarh	142
Hisar	330	Mandikhera	138
Faridabad	322	Durgapur	138
Charkhi Dadri	319	Varanasi	134
Firozabad	318	Panipat	133
Bulandshahr	311	Howrah	129
Vrindavan	307	Jalandhar	129
Manesar	303	Khanna	128
Bhiwani	286	Patiala	125
Agra	282	Hajipur	125
Rohtak	262	Amritsar	124
Bhiwadi	251	Bhatinda	122
Ballabgarh	246	Ludhiana	121
Bahadurgarh	246	Patna	118
Kanpur	232	Dharuhera	111
Kaithal	230	Kolkata	96
Gorakhpur	218	Palwal	85
Kurukshetra	217	Haldia	82
Sonipat	209	Asansol	78
Moradabad	205	Alwar	72
Fatehabad	203	Panchkula	70
Muzaffarnagar	196	Chandigarh	46
		Gaya	44
Note: Average PM _{2.5} concentration is based on mean of daily values recorded at CAAQM stations in the city that have adequate data. Values are based on average daily concentration of four days 4-7 November, 2021. Source: CSE analysis of CPCB's real time air quality data			