

Midway through the winter: Overview of Delhi-NCR air quality during October-November

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There are early signs of improvement in air quality during the first phase of winter in Delhi and National Capital Region (NCR). So far, the average level of PM_{2.5} in this region are lowest in last 8 years. The average of the major cities that are usually more polluted are cleaner in last three years. The winter so far has not recorded any smog episode (when air quality index remains severe for at least three consecutive days or more) in contrast to prolonged episodes during the previous winter.

Diwali falling in warmer October, lower incidents of crop fires that otherwise tips the local pollution over the dangerous levels, pre-emptive action based on pollution forecasting, and favourable meteorological conditions including extended rainfall in October, have all contributed towards bending of the early winter pollution curve. But there may be more spikes later as is usually observed in previous years. Stronger pre-emptive measures and deeper round the year action on local sources is needed to bring down the winter pollution to satisfactory level.

This winter has started on a cleaner note with five “good” AQI days in first two weeks of October. Smog episode events have not been recorded so far. As per SAFAR estimates, smoke contribution from crop burning activities to Delhi’s PM_{2.5} level has gone down to zero as of November 4, 2022 and its overall contribution to Delhi’s PM_{2.5} concentration has been considerably lesser this time.

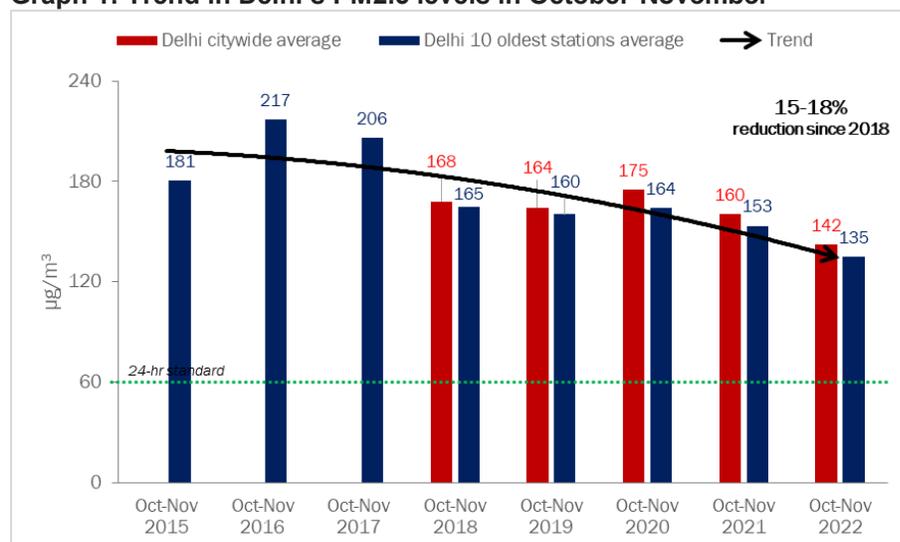
This has emerged from the latest analysis of PM_{2.5} data for the winter months of October-November, 2022, by the Urban Lab at CSE. The objective has been to understand the changing pattern of winter pollution. This also helps to locate the winter season within the longer term context of seasonal variation and annual trends in particulate pollution. This is an assessment of annual and seasonal trends in PM_{2.5} concentration for the period 1 October to 30 November for 2018, 2019, 2020, 2021 and 2022. This analysis is based on the real time data available from the current working air quality monitoring stations in Delhi-NCR. A huge volume of data points have been cleaned and data gaps have been addressed based on USEPA method for this analysis. This analysis covers 81 continuous ambient air quality monitoring stations (CAAQMS) spread across cities of Delhi-NCR. Meteorological data for the analysis is sourced from the Palam weather station of Indian Meteorological Department (IMD). Fire count data is sourced from NASA’s Fire Information for Resource Management System, specifically Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) product is used. Estimate of contribution of farm stubble fire smoke to Delhi’s air quality is sourced from Ministry of Earth Science’s System of Air Quality and Weather Forecasting and Research (SAFAR). This is the first analysis of the third edition of Urban Lab’s Air Quality Tracker Initiative which was started in 2020-21 winter to study the impact of pandemic lockdowns on Delhi’s air quality.

Highlights of the key findings

The early phase of this winter (October-November) was the least polluted in last 8 years in Delhi:

The average PM_{2.5} level across 37 functional CAAQMS stations of Delhi stood at 142 µg/m³ for months of October and November. This is lowest level recorded since city installed these 37 stations in 2018. If data for 10-oldest stations that have been working since 2014-15 is referred, even then October-November of this year is least polluted in comparison (See *Graph 1: Trend in Delhi's PM_{2.5} levels in October-November*). PM_{2.5} level this October-November has been 15 per cent and 18 per cent lower compared to October-November of 2018 from citywide average of 37 stations and 10 oldest stations respectively. Levels have been 38 per cent lower compared to October-November of 2016 that was the worst autumn in last eight years.

Graph 1: Trend in Delhi's PM_{2.5} levels in October-November



Note: 10 oldest stations of Delhi are Anand Vihar, CRRI Mathura Road, IGI Airport T3, IHBAS, Mandir Marg, DU North Campus, NSIT Dwarka, Punjabi Bagh, RK Puram and Shadipur. Delhi citywide average is based on 37 station average includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. October-November average is based on mean of daily averages.

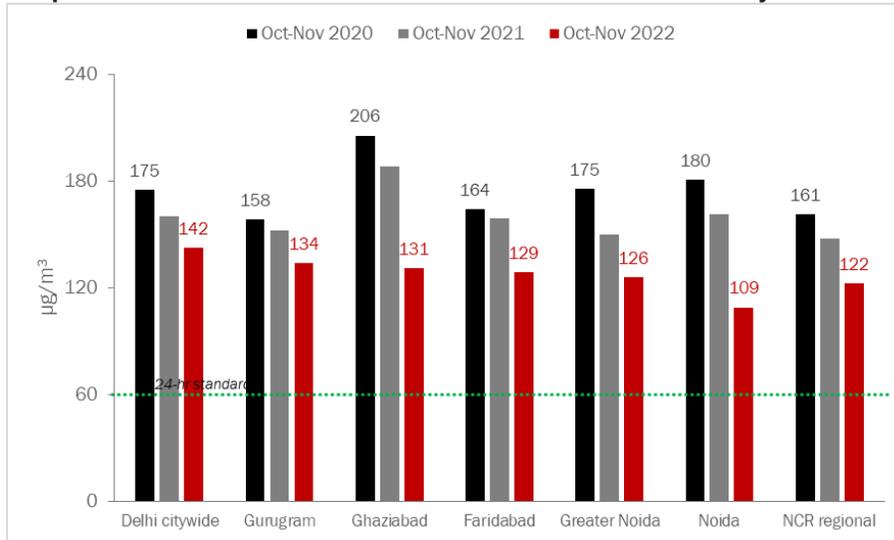
Source: CSE analysis of CPCB realtime data

All major cities of Delhi-NCR that are more polluted than the smaller towns have recorded the least levels in last three years: Ghaziabad's October-November average PM_{2.5} this year is 36 per cent lower than the same period in 2020. Similarly, Greater Noida and Faridabad registered improvement of 28 per cent and 22 per cent respectively. This is higher than Delhi's citywide improvement of 19 per cent in the same time frame. Gurugram shows least improvement with just 15 per cent change (See *Graph 2: Trend in PM_{2.5} levels in October-November for major NCR cities*). Nodia's October-November average PM_{2.5} this year appears to be 40 per cent lower than the same period in 2020. However, it may be noted that one of Nodia's CAAQM stations is reporting uncharacteristically low values this season. This may be examined.

Delhi was the most polluted major city in NCR with October-November average of 142 µg/m³. Gurugram with 134 µg/m³ and Ghaziabad with 131 µg/m³ were the next most polluted in NCR.



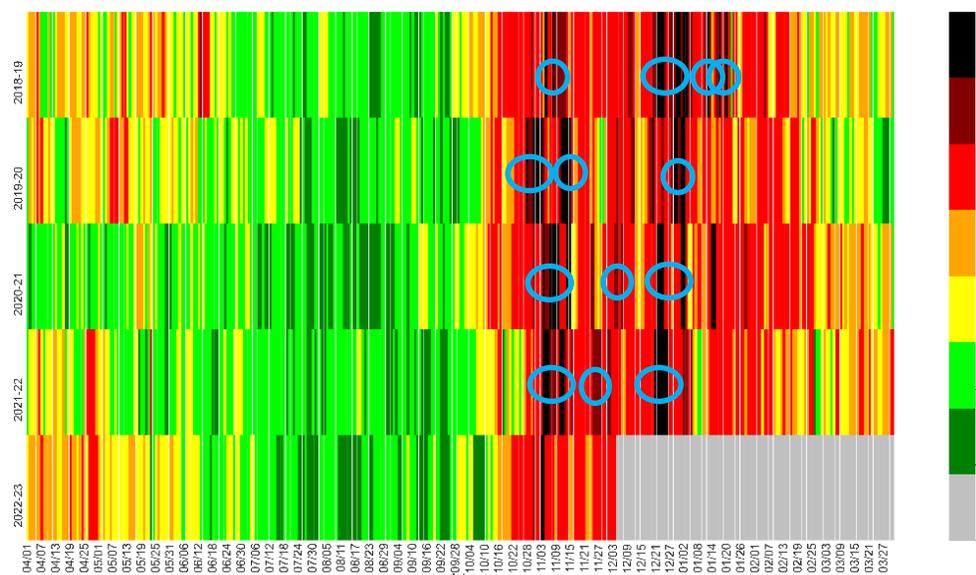
Graph 2: Trend in PM2.5 levels in October-November for major NCR cities



Note: Delhi citywide average is based on 37 station average includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. NCR regional average is based on 78 station average includes all the NCR stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. October-November average is based on mean of daily averages.
 Source: CSE analysis of CPCB realtime data

No severe smog episode (at least three consecutive days with air quality index at severe level) has been recorded so far during this season: There is usually one smog episode during October-November lasting 6-10 days. This October-November no smog episode was recorded in the city (See *Graph 3: Air quality calendar of Delhi*). This makes this October-November first in last five years to be smog free. During the previous winter of 2021, there were three smog episodes – two in November and one in December. November, 2021 had recorded the longest smog episode of 10 continuous days (4-13 November, 2021). Such events have not occurred this winter.

Graph 3: Air quality and smog calendar of Delhi

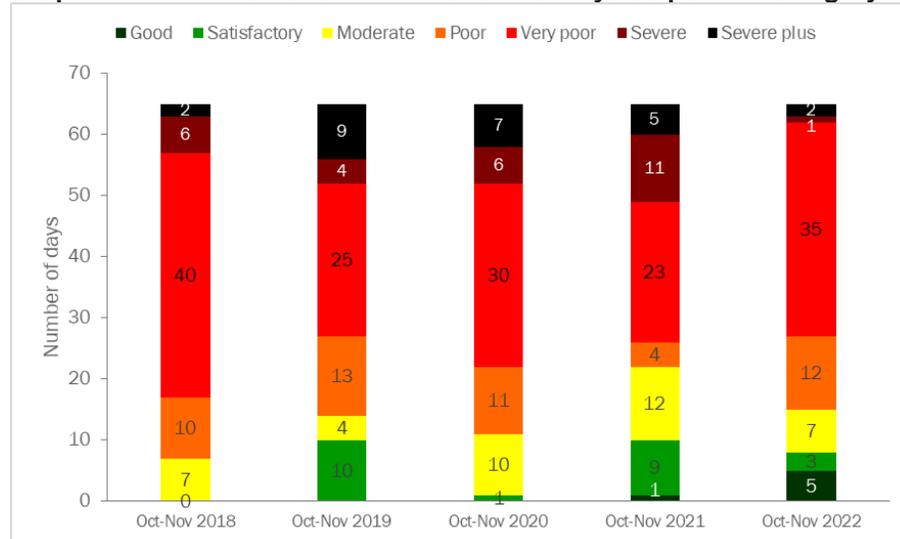


Note: PM2.5 level is based on average of 37 stations which includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. Cell colour is based on the official colour-scheme of AQI sub-categories. Blue loops mark smog episodes.
 Source: CSE analysis



Five good air days recorded this October-November, highest in last five years: Heavy rainfall in October this year has resulted in five days of good air quality (PM2.5 lesser than 30 µg/m3), - this is the maximum number for winter in last five years (See *Graph 4: Distribution of October-November days as per AQI category for Delhi*). Last year there was one good air day while no good air days were recorded in the winters of 2018, 2019 and 2020. Only 3 days of severe or severe-plus days have been recorded so far, which is again the lowest in last five years.

Graph 4: Distribution of October-November days as per AQI category for Delhi



Note: PM2.5 level is based on average of 37 stations which includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. Cell colour is based on the official colour-scheme of AQI sub-categories.

Source: CSE analysis

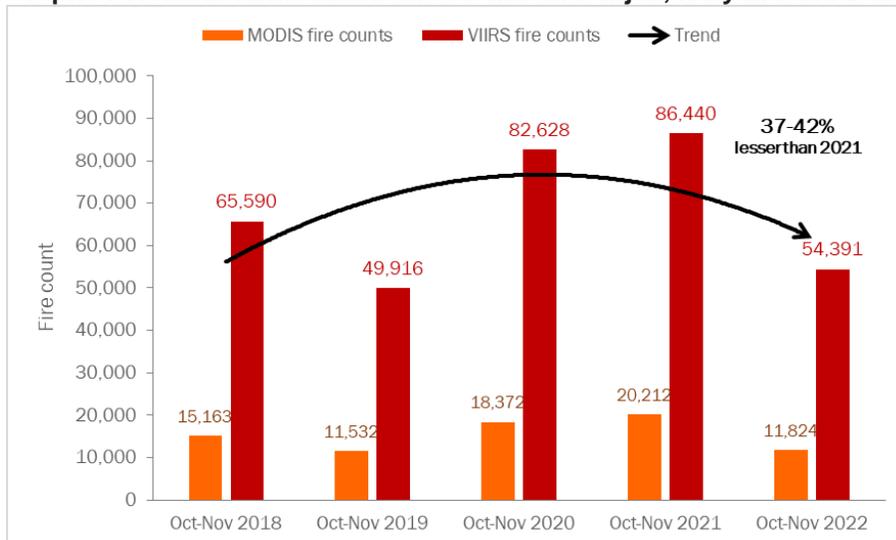
Farm stubble fires this year are about half of the previous year: The total count of farm stubble fires reported this year from Punjab, Haryana and Delhi in months of October and November stood at 54,391 according to NASA’s VIIRS satellite and 11,824 according to NASA’s MODIS satellite (See *Graph 5: Trend in farm stubble fire counts in Punjab, Haryana and Delhi during October-November*). These are respectively 37 per cent and 42 per cent lower than the figures for October-November of 2021.

If the FRP (fire radiative power is measure of intensity of fire) is taken into account in addition to the number of fire, it becomes clear that not only the fires were lesser in count but also lesser in intensity compared to previous two years. The total FRP this October-November has been 363 kW and 187 kW according to VIIRS and MODIS respectively (See *Graph 6: Trend in farm stubble fire power in Punjab, Haryana and Delhi during October-November*). This is 45 per cent and 52 per cent lower than last year’s values of VIIRS and MODIS respectively.

Fires have been lower this October-November both in count and intensity compared to previous two seasons, but are marginally higher compared to 2019 season.



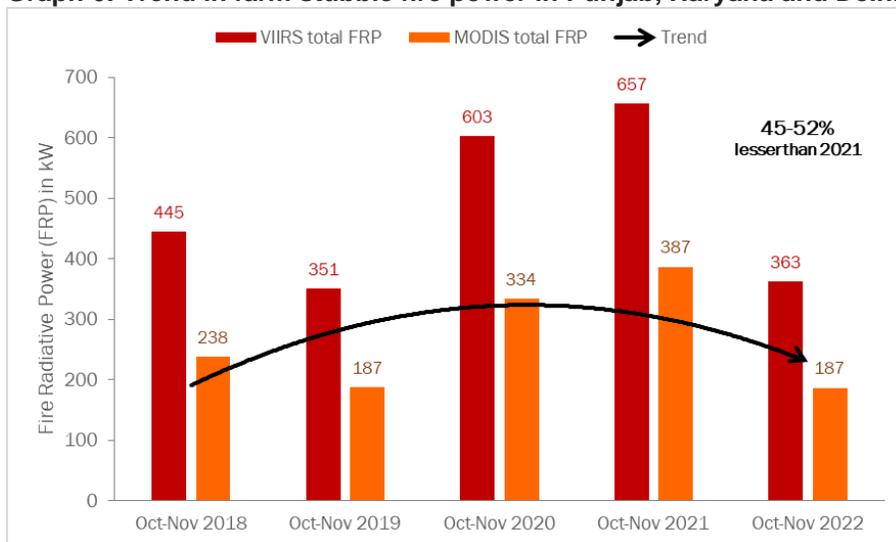
Graph 5: Trend in farm stubble fire counts in Punjab, Haryana and Delhi during October-November



Note: Fire data is based on NASA’s Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) products. It covers Punjab, Haryana and Delhi. Data up till 30 November 2022.

Source: CSE analysis

Graph 6: Trend in farm stubble fire power in Punjab, Haryana and Delhi during October-November



Note: Fire data is based on NASA’s Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) products. Total FRP is calculated as product of average FRP for a day and fire count for that day, done statewide. It covers Punjab, Haryana and Delhi. Data up till 30 November 2022. Source: CSE analysis

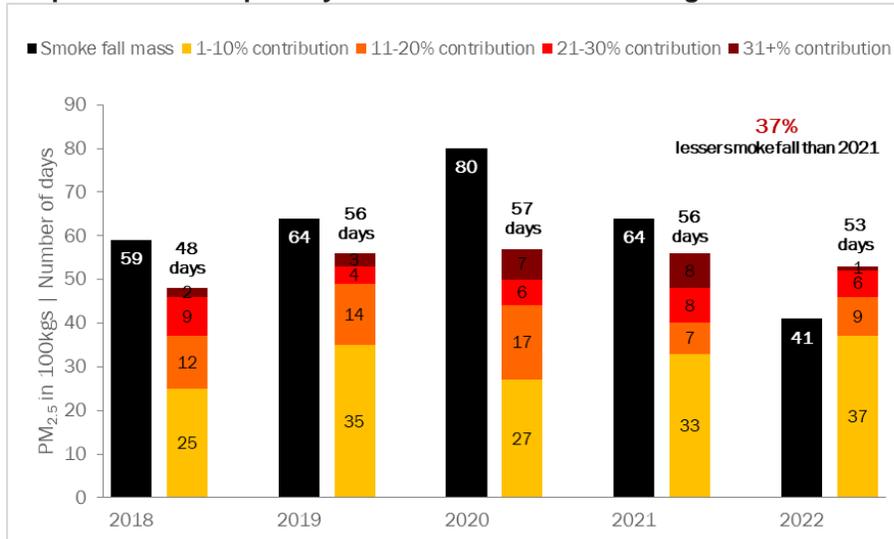
Smoke intrusion from farm fires in Delhi, lowest in last five years: Analysis of the SAFAR data shows that this year smoke from the farm stubble fires contributed to PM2.5 levels in Delhi on 53 days, starting October 12 and ending on December 3. This is lesser than previous three years when smoke intrusion was reported on 56 days, but it is higher than 2018 figure of 48 days. Highest contribution this year was 34 per cent and it was reported on November 3. But given the overall low PM2.5 levels this year, 34 per cent contribution accounts for much lesser in terms of actual PM2.5 concentration in the Delhi’s air. Therefore, it is critical to look also at the absolute mass of PM2.5 that got transported to the city from the fires.

The quantity of smoke from farm stubble fires that falls over Delhi is dependent upon two major factors: quantity and intensity of farm stubble fires, and meteorological conditions conducive for transportation of the smoke to Delhi. This October-November not only the quantity and intensity of farm stubble fires have been comparatively lower but also the meteorological conditions have been less conducive for the transport



of the smoke. As a result, total smoke that invaded Delhi has been considerably lesser. CSE has estimated that smoke has contributed about 4.1 tonne of PM2.5 during October-November in Delhi. This is 37 per cent lesser than 6.4 tonne that fell last year and almost half of 2020 figure (See *Graph 7: Trend in quantity of smoke fall in Delhi during October-November*). The amount is significantly lower than 2019 figure as well which is an indicator of meteorological help Delhi got as farm fires in 2019 were lesser.

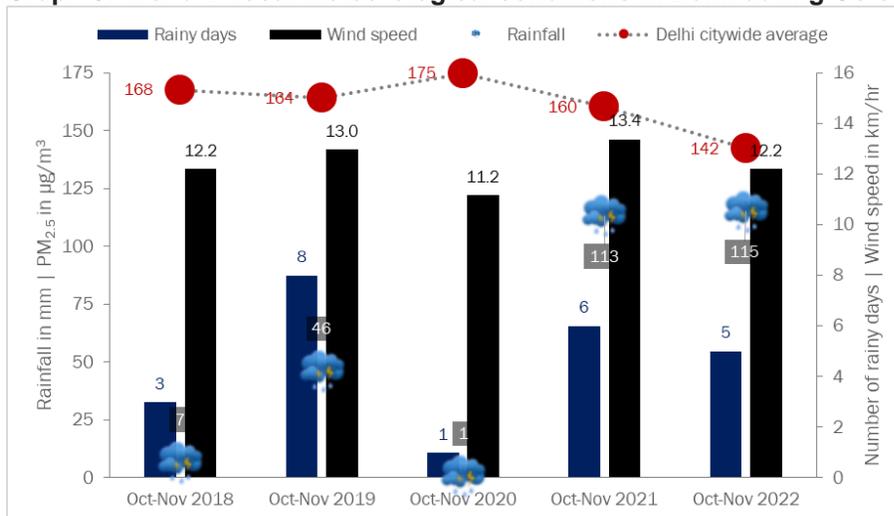
Graph 7: Trend in quantity of smoke fall in Delhi during October-November



Note: Total smoke fall PM2.5 quantity is calculated using SAFAR India's data on farm stubble fire smoke contribution to Delhi's PM2.5 level and daily PM2.5 concentration data based on average of 37 stations of Delhi. The calculation assumes Delhi's geographical area to be 1,483 km² and air slab of 3m from the ground (standard height for placement of the monitoring equipment). Mass of smoke fall is computed for everyday based on SAFAR India and CPCB data, and then added up to arrive at seasonal number. Data up till 4 December 2022. Source: CSE analysis

High rainfall and local wind speed helped disperse local pollution: Delhi received 115 mm of rainfall this October-November, highest in last five years. This helped clean-up the city air, especially in the month of October (See *Graph 8: Trend in local meteorological conditions in Delhi during October-November*). Average wind speed for this November stood at 12.4 km/hr which helped in dispersing local pollution. Average wind speed for 2021 November was 11.0 km/hr and for November 2020 was 11.5 km/hr.

Graph 8: Trend in local meteorological conditions in Delhi during October-November



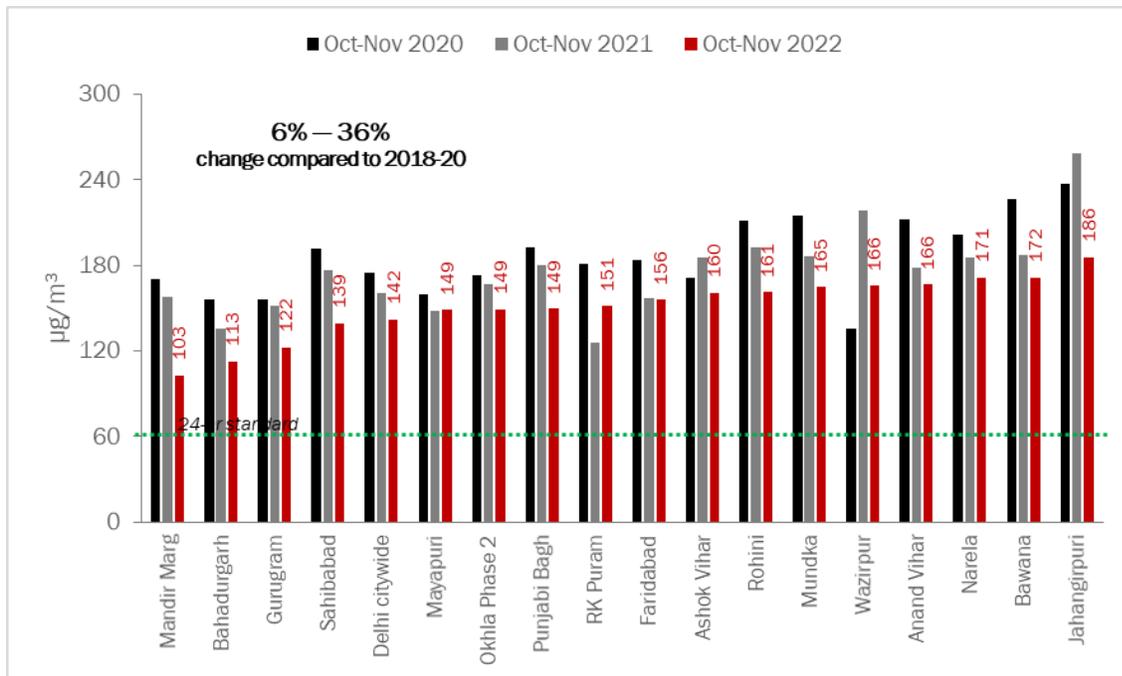
Note: PM2.5 level is based on mean of 37 stations of Delhi. Rainfall and wind speed data is based on average of 5 IMD's stations in Delhi. Source: CSE analysis



Hotspots continue to remain problematic: All hotspots have shown improvement compared to average pollution level recorded in 2018, 2019 and 2020. Mandir Marg has registered most improvement with its October-November levels this year being 36 per cent lower than average of 2018, 2019, and 2020 (See *Graph 11: Improvement in October-November PM2.5 level among the official hotspots compared to 2018-20 average*). Least improvement has been recorded in Mayapuri (6 per cent), Narela (7 per cent) and Ashok Vihar (8 per cent). Wazirpur, Faridabad, and RK Puram registered 11 per cent improvement which is less than the Delhi’s citywide average of 16 per cent.

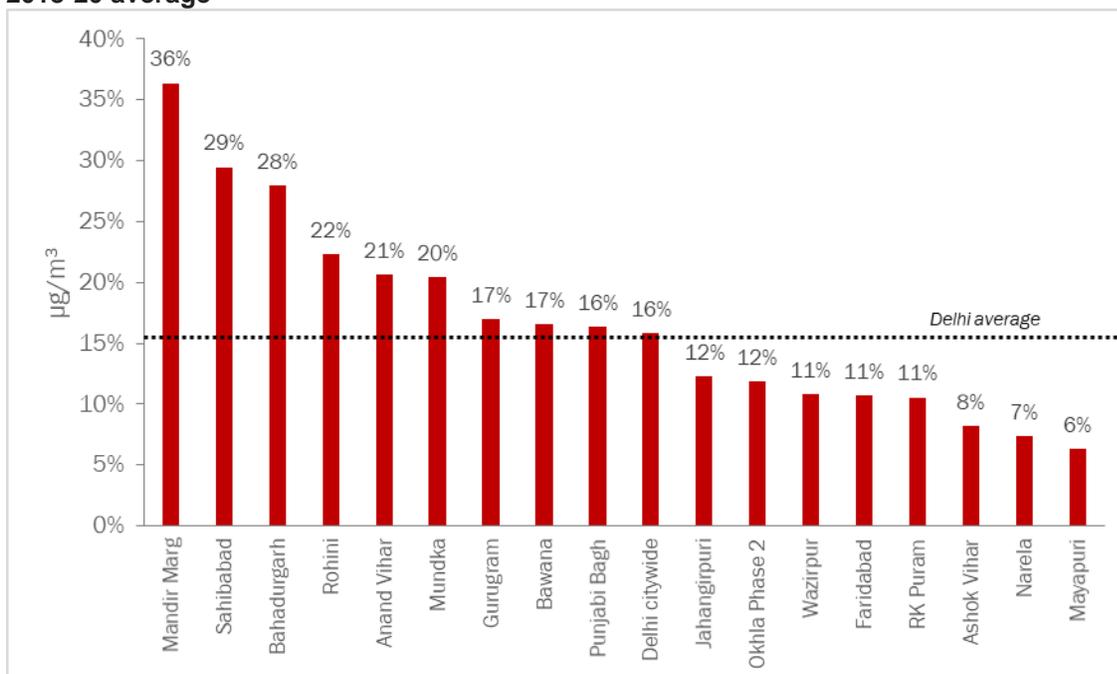
However, hotspots located in North and East Delhi were the most polluted in the city. Jahangirpuri was the most pollution neighborhood with October-November average PM2.5 level of 186 µg/m3 (See *Graph 10: Trend in October-November PM2.5 level among the official hotspots*). Other most polluted hotspots were Bawana (172 µg/m3), Nerela (171 µg/m3), Anand Vihar (166 µg/m3), Wazirpur (166 µg/m3), and Mundka (165 µg/m3). Mandir Marg with 103 µg/m3 and Bahadurgarh with 113 µg/m3 were the least polluted among the official hotspots.

Graph 9: Trend in October-November PM2.5 level among the official hotspots



Note: Delhi citywide average is based on 37 station average includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. October-November average is based on mean of daily averages.
 Source: CSE analysis of CPCB realtime data

Graph 10: Improvement in October-November PM_{2.5} level among the official hotspots compared to 2018-20 average

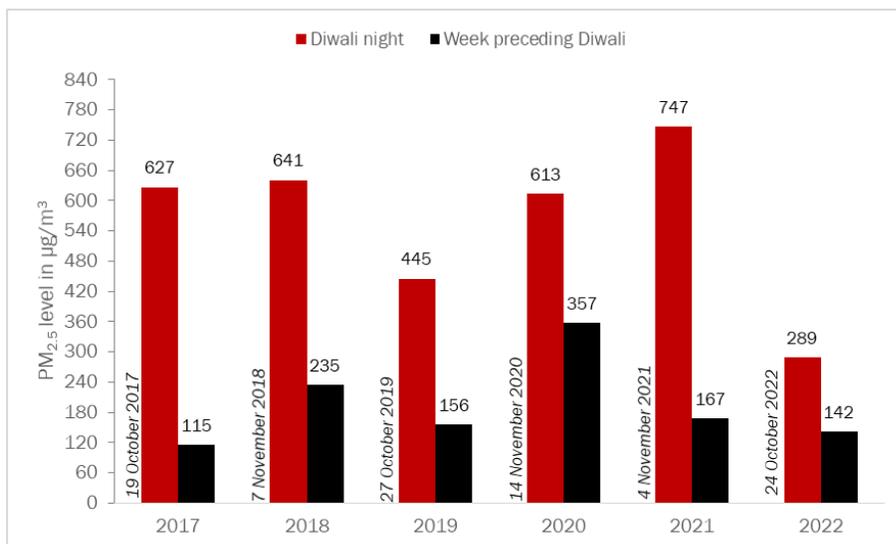


Note: Delhi citywide average is based on 37 station average includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. Improvement is calculated by comparing level of 2022 with average of 2018, 2019 and 2020. October-November average is based on mean of daily averages.

Source: CSE analysis of CPCB realtime data

Most polluted locations in NCR continue to be within Delhi's city limits: Burari Crossing has been the most polluted location in NCR with October-November average of 200 $\mu\text{g}/\text{m}^3$. Jahangirpuri, Nehru Nagar, Vivek Vihar, Bawana, Narela, Alipur, Sonia Vihar, NSIT Dwarka, and Anand Vihar round up the top ten most polluted locations in NCR (See *Table 1: October-November PM_{2.5} level at station levels*). All of them are located within the city limit of Delhi. Mandikhera and Palwal in south Haryana were the least polluted locations in NCR. Alwar in Rajasthan was the third least polluted location.

Least polluted Diwali in last six years: PM_{2.5} concentration on Diwali night (8pm to 8am) this year stood at 289 $\mu\text{g}/\text{m}^3$, a good 61 per cent lower than last year Diwali night when it stood at 747 $\mu\text{g}/\text{m}^3$. Diwali night PM_{2.5} levels almost double of the average night-time levels recorded in the week preceding Diwali. 2021 Diwali night levels were 4.5 times the average night-time levels recorded in the week preceding Diwali (See *Graph 11: Trend in Diwali night pollution in Delhi*). This is an effect of Diwali happening much earlier in the season compared to previous years.

Graph 11: Trend in Diwali night pollution in Delhi

Note: Average PM_{2.5} concentration is based on mean of 12hr values recorded at Delhi's 37 CAAQM stations (2017 Diwali data is based on lesser number of stations). Nighttime is 8pm to 8am. Pre-diwali night average is mean of nighttime levels of seven preceding nights.

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

Take away

The first phase of winter shows bending of the pollution curve compared to the same period during the previous years. This phase has also not seen any severe and prolonged smog episodes that otherwise choke the first phase of winter. It remains to be seen how the rest of the winter will play out. But it is clear that to sustain this change and to improve further more deep rooted interventions are needed throughout the year. The region may have avoided the severe pollution levels. But poor and very poor levels as per the air quality index category are not acceptable from the public health standpoint. Milestones for action in each sector of pollution for the round the year action needs to be set and met urgently to have even cleaner winter next year.

Need to act urgently in Delhi and across NCR:

- Implement industrial clean fuel policy, address small boiler emissions in small scale industry, and eliminate fugitive emissions and industrial waste burning in the entire region.
- Scale up electric mobility, phase out old vehicles, improve on-road emissions monitoring, and rationalise freight movement.
- Scale up public transport services, walking and cycling networks, and implement parking management areas plans with variable parking pricing along with low emissions zones to reduce personal vehicle usage.
- Ensure 100 per cent waste segregation, recycling, remediation of legacy waste in dumpsites to eliminate waste burning.
- Eliminate use of solid fuels for cooking
- Mandate dust control measures in construction, recycling of construction and demolition waste and road dust management.
- Implement urban greening and green walling

Annex

Table 1: October-November PM2.5 level at station levels

| Station | Oct-Nov 2018 | Oct-Nov 2019 | Oct-Nov 2020 | Oct-Nov 2021 | Oct-Nov 2022 |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Burari Crossing, DL | 193 | 166 | | 164 | 200 |
| Jahangirpuri, DL | 219 | 179 | 237 | 259 | 186 |
| Nehru Nagar, DL | 198 | 175 | 193 | 169 | 182 |
| Vivek Vihar, DL | 170 | 189 | 218 | 201 | 178 |
| Bawana, DL | 187 | 203 | 227 | 188 | 172 |
| Narela, DL | 201 | 152 | 202 | 186 | 171 |
| Alipur, DL | 223 | 166 | 197 | 174 | 171 |
| Sonia Vihar, DL | 193 | 148 | 206 | 182 | 167 |
| NSIT Dwarka, DL | 148 | 170 | 85 | 166 | 167 |
| Anand Vihar, DL | 217 | 200 | 212 | 178 | 166 |
| Wazirpur, DL | 222 | 200 | 135 | 219 | 166 |
| Mundka, DL | 215 | 191 | 215 | 186 | 165 |
| Patparganj, DL | 167 | 152 | 196 | 177 | 164 |
| Rohini, DL | 220 | 191 | 212 | 193 | 161 |
| Ashok Vihar, DL | 165 | 188 | 171 | 185 | 160 |
| Sector 16A, Faridabad, HR | 182 | 158 | 183 | 157 | 156 |
| Shadipur, DL | 160 | 126 | 125 | 133 | 155 |
| Sector 51, Gurugram, HR | | | 195 | 163 | 154 |
| Sector 11, Faridabad, HR | | | 159 | 203 | 154 |
| Loni, Ghaziabad, UP | | 213 | 234 | 240 | 152 |
| Sector 62, Noida, UP | 172 | 181 | 190 | 149 | 151 |
| RK Puram, DL | 173 | 153 | 181 | 126 | 151 |
| Punjabi Bagh, DL | 171 | 172 | 193 | 181 | 149 |
| Okhla Phase 2, DL | 170 | 165 | 173 | 167 | 149 |
| National Stadium, DL | 156 | 146 | 153 | 160 | 149 |
| Pusa DPCC, DL | 157 | 159 | 160 | 148 | 149 |
| Dwarka Sector 8, DL | 164 | 177 | 185 | 163 | 149 |
| North Campus DU, DL | 166 | 179 | 178 | 157 | 147 |
| JLN Stadium, DL | 156 | 164 | 159 | 160 | 146 |
| ITO, DL | 173 | 166 | 211 | 171 | 143 |
| Dr KS Shooting Range, DL | 136 | 162 | 184 | 157 | 142 |
| Knowledge Park III, Greater Noida, UP | 176 | 169 | 172 | 150 | 140 |
| Sirifort, DL | 141 | 171 | 159 | 145 | 139 |
| Vasundhara, Ghaziabad, UP | 200 | 200 | 192 | 177 | 139 |
| Sector 116, Noida, UP | | 174 | 176 | 186 | 135 |
| Dharuhera, HR | | 114 | 153 | 110 | 134 |
| Gwal Pahari, Gurugram, HR | 161 | 187 | 140 | 149 | 131 |
| Sri Aurobindo Marg, DL | 139 | 148 | 154 | 138 | 131 |
| Baghpat, UP | 184 | 162 | 186 | 160 | 131 |
| Najafgarh, DL | 137 | 146 | 158 | 134 | 128 |
| CRRM Mathura Road, DL | 212 | 160 | 165 | 162 | 128 |
| Teri Gram, Gurugram, HR | | | 143 | 144 | 128 |
| IGI Airport T3, DL | 130 | 150 | 151 | 133 | 124 |
| Jind, HR | | 155 | 179 | 150 | 122 |
| Vikas Sadan, Gurugram, HR | 163 | 122 | 156 | 151 | 122 |
| Pusa IMD, DL | 131 | 141 | 163 | 138 | 122 |
| Jaibhimnagar, Meerut, UP | | 146 | 176 | 151 | 119 |
| Indrapuram, Ghaziabad, UP | | 187 | 204 | 167 | 118 |
| IHBAS, DL | 121 | 139 | 156 | 157 | 116 |

| | | | | | |
|--|-----|-----|-----|-----|-----|
| Ganganagar, Meerut, UP | | 152 | 136 | 143 | 116 |
| New Industrial Town, Faridabad, HR | | | 157 | 130 | 114 |
| Sanjay Nagar, Ghaziabad, UP | | 215 | 192 | 170 | 113 |
| Aya Nagar, DL | 120 | 142 | 145 | 124 | 113 |
| Bahadurgarh, HR | | 103 | 156 | 136 | 113 |
| Knowledge Park V, Greater Noida, UP | | 172 | 179 | 149 | 112 |
| Muzaffarnagar, UP | 163 | 131 | 138 | 127 | 109 |
| Manesar, HR | | 120 | 138 | 147 | 108 |
| Sector 1, Noida, UP | | 191 | 176 | 156 | 108 |
| Lodhi Road, DL | 136 | 144 | 116 | 134 | 107 |
| Pallavpuram, Meerut, UP | | 177 | 163 | 160 | 105 |
| Mandir Marg, DL | 160 | 156 | 170 | 158 | 103 |
| Bulandshahr, UP | 174 | 128 | 184 | 145 | 102 |
| Charkhi Dadri, HR | | | 167 | 137 | 102 |
| Bhiwani, HR | | 118 | 48 | 109 | 98 |
| Bhiwadi, RJ | 146 | 119 | 178 | 149 | 97 |
| DTU, DL | 185 | 183 | 209 | 178 | 97 |
| Rohtak, HR | 69 | 122 | 144 | 130 | 94 |
| Sector 30, Faridabad, HR | | | 157 | 146 | 91 |
| Hapur, UP | 191 | 115 | 71 | 160 | 90 |
| Ballabgarh, HR | | 106 | 123 | 146 | 88 |
| Sonipat, HR | | 67 | 88 | 96 | 84 |
| Karnal, HR | | 129 | 108 | 103 | 78 |
| Narnaul, HR | | 90 | 83 | 89 | 66 |
| Panipat, HR | | 160 | 96 | 89 | 57 |
| Alwar, RJ | 44 | 41 | 55 | 53 | 47 |
| Palwal, HR | | 132 | 55 | 53 | 34 |
| Mandikhera, HR | | 111 | 92 | 73 | 27 |
| Sector 125, Noida, UP* | 181 | 177 | 180 | 155 | 41 |
| EastArjunNagar, DL* | | | | | |
| Chandni Chowk IITM, , DL* | | | 152 | 119 | |
| Lodhi Road IITM, DL* | | | 106 | 126 | |

Note: October-November average is based on mean of daily averages. All values are in $\mu\text{g}/\text{m}^3$.

*Stations with incomplete or suspect data.

Source: CSE analysis of CPCB realtime data