

Pandemic and air pollution in Delhi-NCR: Insights on World Environment Day

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On this World Environment Day, Centre for Science and Environment releases the latest results of air quality analysis that shows how air quality trend has changed through the successive seasons during the pandemic times in Delhi and National Capital Region (NCR). This assessment period is from September 2018 to May 2021 that captures three successive winter seasons, pre and pandemic era and also different stages of lockdown in Delhi and the National Capital Region.

The key highlight this time is that the spring time – January to March, when pollution level begins to subside after winter, PM_{2.5} this year has recorded highest seasonal levels compared to the corresponding period in preceding years including the normal year of 2019.

This indicates that despite the partial restrictions the pollution level have increased. While the reason needs investigation, it is important to underscore that there would be a rebound effect with full opening of the economy and intensification of traffic. Pandemic management during the second wave may have slowed down action but this has to speed up to prevent the rebound effect or retaliatory emissions to ensure longer term air quality gains. This is particularly important given the new science on the linkage between air quality and its effect on vulnerability to the pandemic.

This analysis is based on the real time data available from the current working air quality monitoring stations in Delhi and NCR. However, even though Delhi's monitoring network grew to 40 AQM stations by the end of 2020 (24 of Delhi Pollution Control Committee or DPCC, 8 of IMD, 6 of Central Pollution Control Board -CPCB and 2 of IITM), the number of active stations have reduced to 32 as all the IMD stations have gone offline. IMD's station at Burari Crossing has been offline since 13 Dec, 2020 while Ayanagar, CRRI Mathura Road, IGI Airport, Lodi Road, North Campus DU, and PUSA stations went offline on March 10, 2021. In fact, their two other stations (Gwal Pahari, Gurugram and Noida Sector 62) have also gone offline.

As far as data availability is concerned there is a wide variation between monitoring locations. While over 90 per cent of hourly data is available for all DPCC and CPCB stations for the time period between 1 January to 31 May, 2021, data availability for two IITM stations is 75-86 per cent. HSPCB stations in Gurugram shows over 90 per cent data availability, but the stations in Faridabad has only 70-89 per cent data available. UPSPCB stations in Nodia, Ghaziabad and Greater Nodia have over 85 per cent data available except the stations at Noida Sector 125 and Greater Noida Knowledge Park-III which have just 65 per cent data.

Overall, monitoring network strength in Delhi and big five NCR cities has come down from 58 stations to 48 stations now. This along with lower availability of data at many stations is a matter of concern as this makes the investments in monitoring network sub-optimal.

Key highlights

The broad sweep trend in PM_{2.5} levels from September 2018 to May 2021: The overall annual trend is arrested and is downward. But there is a variation in seasonal pattern. Normally, PM_{2.5} level have a seasonal cycle with winter being the most polluted and monsoon being the cleanest. Spring (January to March) acts as transitional period between the two extremes – winter and summer. Significant drop in PM_{2.5} levels happens as the weather warms up and wind picks up speed during spring. There was a 26 per cent drop between winter of 2018 and spring of 2019. In 2020 this drop increased to 36 per cent due to pollution control measures in place and also imposition of partial lockdowns in March 2020. But this downward trend in spring pollution did not continue this year, with seasonal drop limited to 18 per cent. In



fact, spring this year has been 31 per cent dirtier than 2020 and 8 per cent dirtier than 2019 (See *Graph 1: Daily and seasonal trend in PM*_{2.5} *levels in Delhi*).

Lockdown with a difference: Lockdowns were effective in bringing down PM_{2.5} levels this year as well. But given the shorter duration and lesser stringency of lockdowns this year PM_{2.5} levels are not as low as summer of 2020. The monthly average level of PM_{2.5} in April and May, 2021 – the hard lockdown phase, was higher than the corresponding levels in April-May, 2020, – also a hard lockdown phase.

Meteorology would be part responsible for this elevated level but this could also be a reflection of weakening of pollution control measures and efforts in the city and region during the pandemic phase. Traffic intensity was also comparatively higher. Evening peak of hourly cycle of NO₂ was 29 per cent higher in 2021 hard-lockdown than observed in 2020 hard lockdown (See *Graph 2: Hourly NO₂ cycle in Delhi*). But it was still 57 per cent lower than regular evening peak noted in May of 2019.



Graph 1: Daily and seasonal trend in PM_{2.5} levels in Delhi

Note: Average PM_{2.5} concentration is based on mean of daily values recorded at 26 CAAQM stations in the city that have adequate data for all three years.



Graph 2: Hourly NO₂ cycle in Delhi



Note: Average NO_2 concentration is based on mean of hourly values recorded at all CAAQM stations in Delhi that have adequate data for all three years.

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

The month of May which was completely under lockdown saw Delhi and big four cities record identical $PM_{2.5}$ levels (See *Graph 3: 2021 Lockdown PM_{2.5} levels in Delhi and big four NCR cities*). Ghaziabad with monthly average of 59 µg/m³ was the most polluted during the lockdown while Gurugram with 51 µg/m³ was the cleanest. Average for the year so far (January to May) shows similar spatial trend among the cities.



Graph 3: 2021 Lockdown PM_{2.5} levels in Delhi and big four NCR cities 2021

Note: Average $PM_{2.5}$ concentration is based on mean of daily values recorded at CAAQM stations in each city that have adequate data for this years.



Varying pattern of hard lock down phase and semi-lockdown phase of 2020 and 2021: This year restriction in form of night-curfews and weekend lockdowns started on April 6 with complete lockdown being imposed on April 19. Imposition of partial-lockdown lowered PM_{2.5} levels by 20 per cent, the complete lockdown brought the average down by further 12 per cent (See *Graph 4: Comparison of lockdown phases in Delhi*).

In 2020, partial lockdown started 12 March, 2020 with hard lockdown kicking in on March 25, which was lifted in phase-wise manner from May 18 onwards. Then the partial lockdown also brought PM_{2.5} levels down by 20 per cent but the hard lockdown reduced it by another 35 per cent. Lifting of restriction from May 18 led to 28 per cent rise in PM_{2.5} levels.

When compared to summer of 2019 which had no lockdowns, lockdown summers have been 25-40 per cent cleaner.



Graph 4: Comparison of lockdown phases in Delhi

Note: Average $PM_{2.5}$ concentration is based on mean of daily values recorded at 26 CAAQM stations in the city that have adequate data for all three years.

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

Heat map of daily air quality pattern during 2019 to 2021 show the changing pattern of smog episodes and cleaner days in Delhi and NCR: Daily PM_{2.5} levels have been further classified according to the air quality index categories. The number of days in the very poor AQI PM_{2.5} sub-category dramatically increased in Feb-March of 2021 (See *Graph 5: Heatmap of Delhi's daily PM_{2.5} AQI sub-category*). There were 27 days of "very poor" days this Feb-March compared to 17 in 2020 and 12 in 2019. Days meeting the standard also plummeted this spring with just two days recorded. 2020 had 16 and 2019 had 6 days when the standard was met. This red shift breaks the three year trend of accelerated dissipation of bad winter air.





Graph 5: Heatmap of Delhi's daily PM_{2.5} AQI sub-category

Note: Average $PM_{2.5}$ concentration is based on mean of daily values recorded at 26 CAAQM stations in the city that have adequate data for all three years. Cell colors are based on AQI color scheme based on their 24-hourly averge. Source: CSE analysis of CPCB's real time air quality data

Number of days with severe concentration of PM_{2.5} declined while duration of smog episodes were shorter during 2020-21 winter: This winter 23 days had citywide average of PM_{2.5} concentration in "severe' or worse AQI sub-category, this is down from 25 such days in pervious winter and 33 days in 2018-19 winter (See *Graph 6: Decline in number of "severe" and worse air days in Delhi*). Technically, a smog episode is defined for the purpose of implementing emergency action under the Graded Response Action Plan when the levels of PM_{2.5} remain in "severe" category for three consecutive days. From this perspective, this winter there were two continuous smog episodes. The first episode was of longer duration as it started on 3rd November and lasted 7 days. The second started on 22nd Dec and lasted for 3 days (See *Graph 7: Map of smog episode in Delhi*). Thus the continuous smog episodes are fewer and shorter compared to previous winters. 2019-20 winter had three smog episodes of 8 days, 6 days and 5 days durations.

Relatively faster dissipation of smog episodes without any major rainfall or pollution control-emergency action this year points towards downward trend in the annual average concentration. This period also coincide with the gradual unlocking of economy and travel in the air shed (perhaps residual impact of lockdown). But still persistent high level suggest impact of local pollution.





Graph 6: Decline in number of "severe" and worse air days in Delhi (1 Oct- 31 Jan)

Note: Average $PM_{2.5}$ concentration is based on mean of daily values recorded at 35 CAAQM stations in the city that have adequate data for all three winters.

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



Graph 7: Map of smog episode in Delhi

Note: Average $PM_{2.5}$ concentration is based on mean of daily values recorded at 35 CAAQM stations in the city that have adequate data for all three winters.



Shifting position of city hotspots in relation to the city average over the three winters - 16 of 18 recognized hotspot registered worsening of air: There is a broad classification of hotspots. Originally, hotspots were defined as those with annual average levels higher than the mean value of the city – that is any case is much worse than the national ambient air quality standards. According to the original list, except Wazirpur and Sahibabad, all the locations on Delhi-NCR pollution hotspot list saw spike in the seasonal PM_{2.5} level compared to last winter. Jahangirpuri with a seasonal average of 256 μ g/m³ was the dirtiest among the recognized hotspots. Bahadurgarh that recorded almost 50 per cent jump in PM_{2.5} level was cleaner than other hotspots. But heavier deterioration was noted in many other locations that are not yet designated as hotspots.

However, during the winter months, at least 14 more locations registered higher seasonal average than the mean of recognized hotspots, i.e. 197 μ g/m³ (See *Graph 8: Winter pollution at hotspots*). These were Alipur, DTU, ITO, Nehru Nagar, Patparganj, Sonia Vihar and Vivek Vihar in Delhi, Sector 1 and 116 in Noida, Loni, Sanjay Vihar and Indirapuram in Ghaziabad, Knowledge Park V in Greater Noida and Bulandshahr. This again points towards impact of local pollution.



Graph 8: Winter pollution at hotspots

Note: Average PM_{2.5} concentration is based on mean of daily values recorded at the CAAQM stations given it has adequate data for the winter. Mayapuri and Sahibabad don't have a CAAQM station, therefore nearest station to them (Pusa DPCC and Vasundhara respectively) is used to represent their air quality. Gurugram and Faridabad are represented by their oldest station. Vikas Sadan and Sector 16A respectively.

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

Behavior of pollution hotspots during lockdowns: If we look at places that reported relatively higher PM_{2.5} levels during the lockdown this year, the hotspots (old and new) occupy the top of the list without exception (See *Table 1: Location wise data for month of May, 2020*). Further, 21 out of 43 stations that have data for both this lockdown and 2020 lockdown show improvement in PM_{2.5} levels. Among stations that saw improvement Panjabi Bagh (-42 per cent) was the best followed by Rohini (-21 per cent) and Dilshad Garden (-20 per cent). Almost all sites with improvement are primarily residential in nature.

Most significant increase is noted at RK Puram (51 per cent) followed by Patparganj (45 per cent), Sadipur (36 per cent), and Mandir Marg (30 per cent). The increase in Mandir Marg and Sadipur can be due to ongoing construction work at Central Vista as these stations are downwind of the construction.



Table 1: Location wise data for month of May, 2020 May-21 May-20 Change* Sector 11, FD 77.7 Loni, GHZ 77.2 69.4 11% Bawana, DL 74.1 80.0 -7% **NSIT Dwarka, DL** 72.0 71.3 1% Anand Vihar, DL 71.4 0% 71.1 Sector 30, FD 70.0 63.4 10% Patparganj, DL 68.4 47.0 45% 4% DTU, DL 68.3 65.4 Sector 51, GGN Narela, DL 14% 65.0 57.1 63.9 72.5 -12% New Industrial Town, FD 63.2 Sonia Vihar, DL 54.7 14% 62.5 Vivek Vihar, DL 62.4 53.3 17% 66.0 Alipur, DL -7% 61.3 Vasundhara, GHZ 61.3 56.9 8% Mandir Marg, DL 61.1 47.1 30% Jahangirpuri, DL 60.8 65.2 -7% **RK Puram, DL** 59.6 39.5 51% Mundka, DL 59.2 64.2 -8% 71.2 -21% Rohini, DL 56.4 Wazirpur, DL 56.3 59.1 -5% Punjabi Bagh, DL 56.3 96.4 -42% Lodhi Road (IITM), DL 56.1 Sanjay Nagar, GHZ 54.8 63.1 -13% Noida Sector 116 54.0 48.0 13% Sector 16A, FD 53.6 42.3 27% Ashok Vihar, DL 52.8 -5% 55.4 Noida Sector 125 52.1 46.8 11% Najafgarh, DL 51.4 59.3 -13% Shadipur, DL 51.4 37.9 36% Vikas Sadan, GGN 51.3 50.1 2% Knowledge Park V, GND 50.7 12% 45.5 Dwarka Sector 8, DL 50.6 51.4 -1% TeriGram, GGN 50.5 56.4 -10% Nehru Nagar, DL 48.2 50.0 -4% Indirapuram, GHZ 46.1 51.1 -10% Okhla Phase 2, DL 45.6 47.2 -3% **IHBAS Dilshad Garden, DL** 45.5 57.2 -20% 3% Knowledge Park III, GND 45.3 44.0 JLN Stadium, DL 45.2 43.2 5% Sirifort, DL 44.7 47.0 -5% Dr KS Shooting Range, DL 44.5 34.6 29% Pusa (DPCC), DL 44.4 49.7 -11% Sri Aurobindo Marg, DL 2% 44.2 43.2 MDC National Stadium, DL 42.3 44.2 -4% Noida Sector 1 41.7 51.6 -19% Chandni Chowk, DL 38.1 Aya Nagar, DL 76.2 ITO, DL 72.6 Lodhi Road (IMD), DL 55.3 **CRRI** Mathura Road, DL 54.4 **IGI** Airport T3, DL 54.2 Gwal Pahari, GGN 52.0 North Campus, DL 50.8 Noida Sector 62 50.4 Pusa (IMD), DL Burari Crossing, DL East Arjun Nagar, DL

Note: * negative value means reduction in PM2.5 this year. Blank cells means no data or not enough data available to compute monthly average. Values in $\mu g/m^3$



Highlights of key pollution episodes

Dust event in May 2021: In the morning of 23^{rd} May, Delhi woke up to strange yellow haze with city's AQ monitors blinking red with PM_{2.5} levels in severe level. This haze appeared straight after the wettest week with strong winds in May in Delhi that was affected by the cyclone Tauktae. PM₁₀ levels that is affected more by coarse dust shot up 10-folds within 4 hours, while PM_{2.5} rose about 5-folds. At its peak PM₁₀ was beyond 1,000 µg/m³ while PM_{2.5} was 469 µg/m³, i.e. 47 percentage (See *Graph 9: PM hourly peak during cyclonic dust event in May 2021*). Winter pollution at hotspots). The haze disappeared almost as quickly as it had appeared. This was a rare meteorological phenomena in which cyclonic systems carried dust along.





Note: $PM_{2.5}$ concentration is based on mean of hourly values recorded at all CAAQM stations in the city that have adequate data for the event.

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

Winter smog: During the dust event in May 2021, though the PM levels for those few hours were as high as that noted during infamous Delhi smog but it was chemically and physically different. During the winter smog episode that peaked on November 10, 2020 the PM_{2.5} was almost 90 per cent of the PM10 in the air. And this peak had built-up over two days (See *Graph 10: PM hourly peak during smog event in November 2020*). This early November smog is also a result of winds transporting PM and smoke from stubble burning in northern plains. SAFAR noted that over 20 per cent of PM_{2.5} in Delhi came from the stubble fire smoke during this period.





Graph 10: PM hourly peak during smog event in November 2020

Note: $PM_{2.5}$ concentration is based on mean of hourly values recorded at all CAAQM stations in the city that have adequate data for the event.

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

Another high PM event happened in Delhi in January when cold weather and calm wind trapped local pollution spiking PM concentration. Peak of this seasonal phenomena happened on January 15, 2021 when PM₁₀ rose to 744 µg/m³ and PM_{2.5} hit 499 µg/m³. PM_{2.5} was 67 per cent of the overall PM concentration (See *Graph 11: PM hourly peak during pollution inversion event in January 2021*). This had a diurnal cycle with peak almost always occurring late night, loosely linked to traffic rush hours.

Yet another PM event is associated with Diwali. It builds-up rapidly and is very toxic.



Graph 11: PM hourly peak during pollution inversion event in January 2021

Note: PM_{2.5} concentration is based on mean of hourly values recorded at all CAAQM stations in the city that have adequate data for the event.