A CSE BRIEFING NOTE

Air pollution at the onset of winter in Delhi: Smokescreen of farm fires cannot hide local sources of air pollution

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At the onset of the winter and just before the anticipated peaking of episodic air pollution from the stubble burning and bursting of fire crackers during Diwali, the Centre for Science and Environment (CSE) has carried out an analysis of the current trends in PM2.5 levels in this early phase of winter to understand the nature of change in air quality and the changing pattern of the contribution of different sources of air pollution to overall particulate pollution in Delhi.

This analysis focuses on PM2.5 concentration trends from September 15 to October 28, 2024, and also compares this time frame with the corresponding time zone during the past years.

This analysis has been done is based on the i) publicly available granular real time data from the CPCB's official online portal Central Control Room for Air Quality Management. The data has been captured from 37 official stations under the Continuous Ambient Air Quality Monitoring System (CAAQMS) spread across Delhi. Ii) Dynamic estimation of real-time data on source contribution by the Decision Support System for Air Quality Management of the Indian Institute of Tropical Meteorology (IITM) to assess the real-time trend in the relative contribution of different sources of pollution. iii) Farm fire counts from the Indian Agricultural Research Institute (IARI) and contributions from farm stubble fires to Delhi's air quality, as estimated by the Ministry of Earth Science's SAFAR (System of Air Quality and Weather Forecasting and Research). Iv) Additional analysis has also been done to assess the change in traffic speed in the city –a measure of congestion during early winter (September 15 –October 27, 2024) on 15 road stretches of key roads in Delhi and relate it with the pollution trends.

Usually every year, the contribution of farm fires to Delhi's air quality during this first phase of winter is considered the biggest problem, detracting attention form the local sources of air pollution. But this year, the air quality of Delhi has turned poor to very poor even when for most part of this phase, the contribution of farm fires has remained less than one to three per cent, reaching upto 8-16 per cent only on two days. This exposes the problem of higher contribution of local air pollution sources.

What is stunning is the very high contribution of vehicles among the local sources of Delhi, to Delhi's air quality – its more than half. With the overall number of farm fire count declining, the city cannot hide behind its smokescreen anymore. This demands very stringent advanced action at scale and with speed to minimize the local pollution is Delhi and in the surrounding region.

Moreover, the PM2.5 levels during this phase of winter of 2024 appear to be similar and even higher higher compared to the same time frame during the previous winters, suggesting that air quality has not improved substantially and is at risk at worsening.

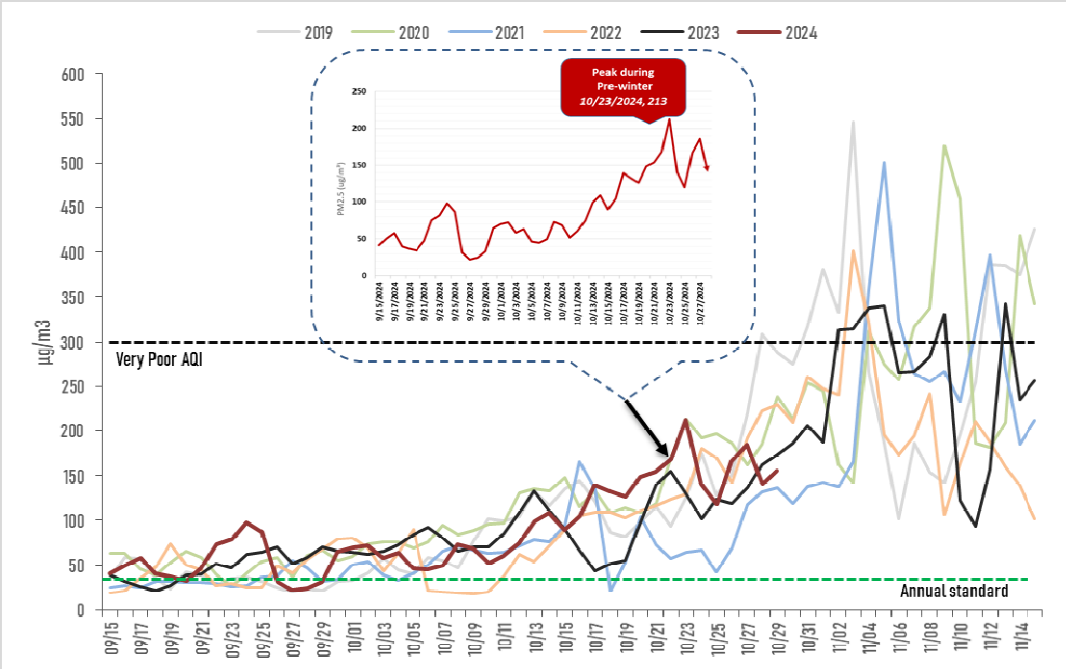
An added challenge has been the escalation in congestion index of major roads across Delhi that has further aggravated the pollution exposure. Vehicles caught in congestion and idling emit several times more than their normal on-road emissions.

Key Highlights

Air quality trends at the onset of winter – steady deterioration: Delhi's air quality has begun its seasonal incline, with PM2.5 levels surpassing 100 µg/m³ on October 14 *(See Graph 1: Daily trend of PM2.5 level in Delhi).* While this level remains lower compared to previous years, it is expected to climb

sharply in the coming days. The highest PM2.5 spike this early-winter season (Sept 15 - Oct 28) was recorded on October 23, reaching 213 µg/m³ when the contribution of farm fire was 16 per cent. However, the average PM2.5 level during October 1 to October 28 shows that a increase of about 13 per cent compared to the corresponding period in 2023.

Graph 1: Daily trend of PM2.5 level in Delhi

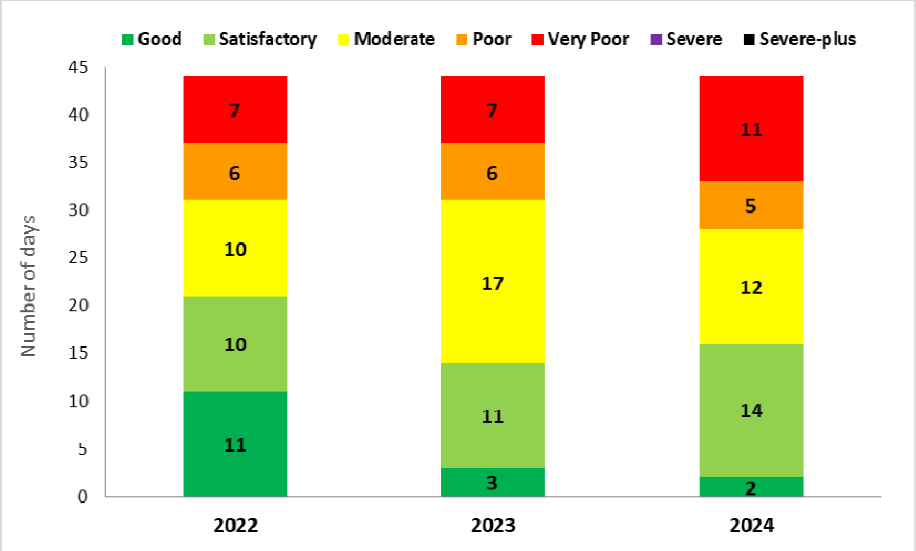


Note: PM2.5 level is based on the mean of 37 stations in Delhi. Data up till 28 October 2024*.
Source: CSE analysis of CPCB real-time data

During the first phase of this winter season, more very poor and poor air quality days have been recorded while the number of good air quality days have reduced drastically: Eleven 'very poor' air days were recorded during this period under scrutiny – which is highest for the same period in the last three years (Sept 15- Oct 28)**.** During the pre-Diwali period under scrutiny this year, eleven days have recorded 'very poor' air quality days and five 'poor' days. Altogether, there were 16 'very poor' and 'poor' days this season, up from 13 days in each of the previous two years. (See *Graph 2: Distribution of days as per AQI category for Delhi (15 September – 28 October*)). In contrast, the same period in 2022 and 2023 had recorded 7 'very poor' days each.

Conversely, 'good' air quality days have sharply declined, dropping from eleven days in 2022 to just 2 days in 2024.

Graph 2: Distribution of days as per AQI category for Delhi (15 September- 28 October)

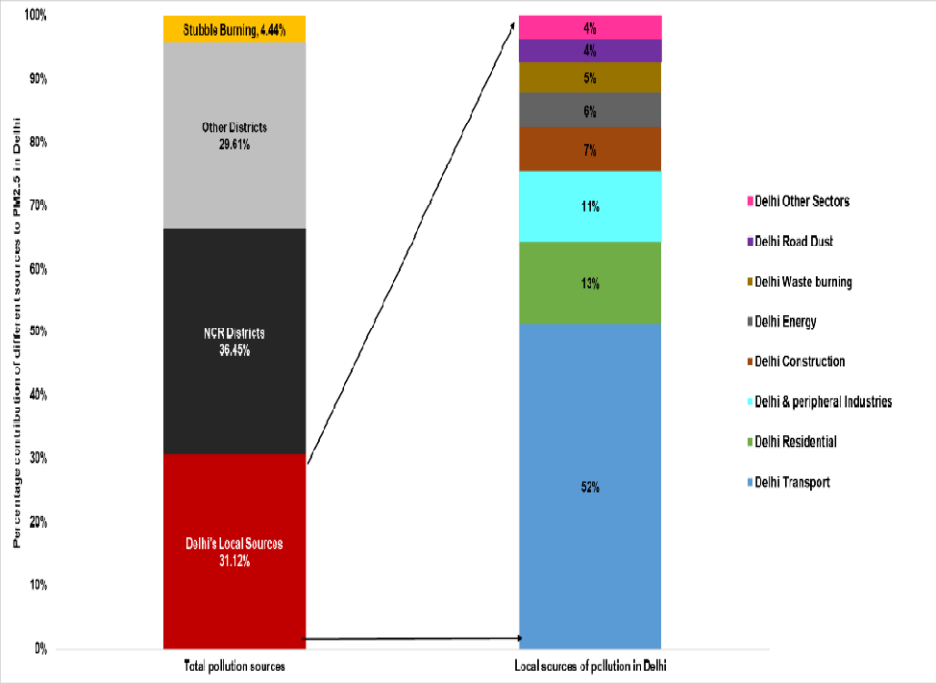


Note: Average $PM_{2.5}$ concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for all years. Data is from (15 Sept 2024 – 28 Oct) for all years. Source: CSE analysis of Central Pollution Control Board (CPCB's) real-time air quality data.

What is contributing to Delhi's PM2.5 concentration now? CSE has analyzed the real time dynamic estimation of the relative contribution of different pollution sources to Delhi's air quality put out by the Indian Institute of Tropical Meteorology (IITM)' Decision Support System (DSS). The DSS provides insight into the fractional contribution to PM2.5 in Delhi from 29 sources out of which eight are in Delhi (local sources) and the rest are outside Delhi. This analysis has selected eight local sources that DSS has attributed as local sources to Delhi. CSE has accessed data for every day for the period October 12- 27 (24-hour average). (see Graph 2: Fractional contribution of various sources of pollution to PM2.5 in Delhi (October 12–27, 2024). Contribution of each local source of pollution has been assessed. The pollution sources include transport, industry, construction, waste burning, energy, residential source, road dust and other group of sources.

Nature of influence of sources from outside Delhi: During this phase, the overall contribution of farm fires has remained only 4.44 per cent. But there has been substantial intrusion from in the surrounding region of Delhi – amounting to 66 per cent – implicating a range of other sources of pollution. The contribution from "other districts" include the districts of Haryana, UP, MP, Bihar, Rajasthan, etc that are outside the NCR. This demands a region-wide and airshed based mitigation strategy.

Graph 3: Average fractional contribution of various sources of pollution to PM2.5 in Delhi (October 12–27, 2024)

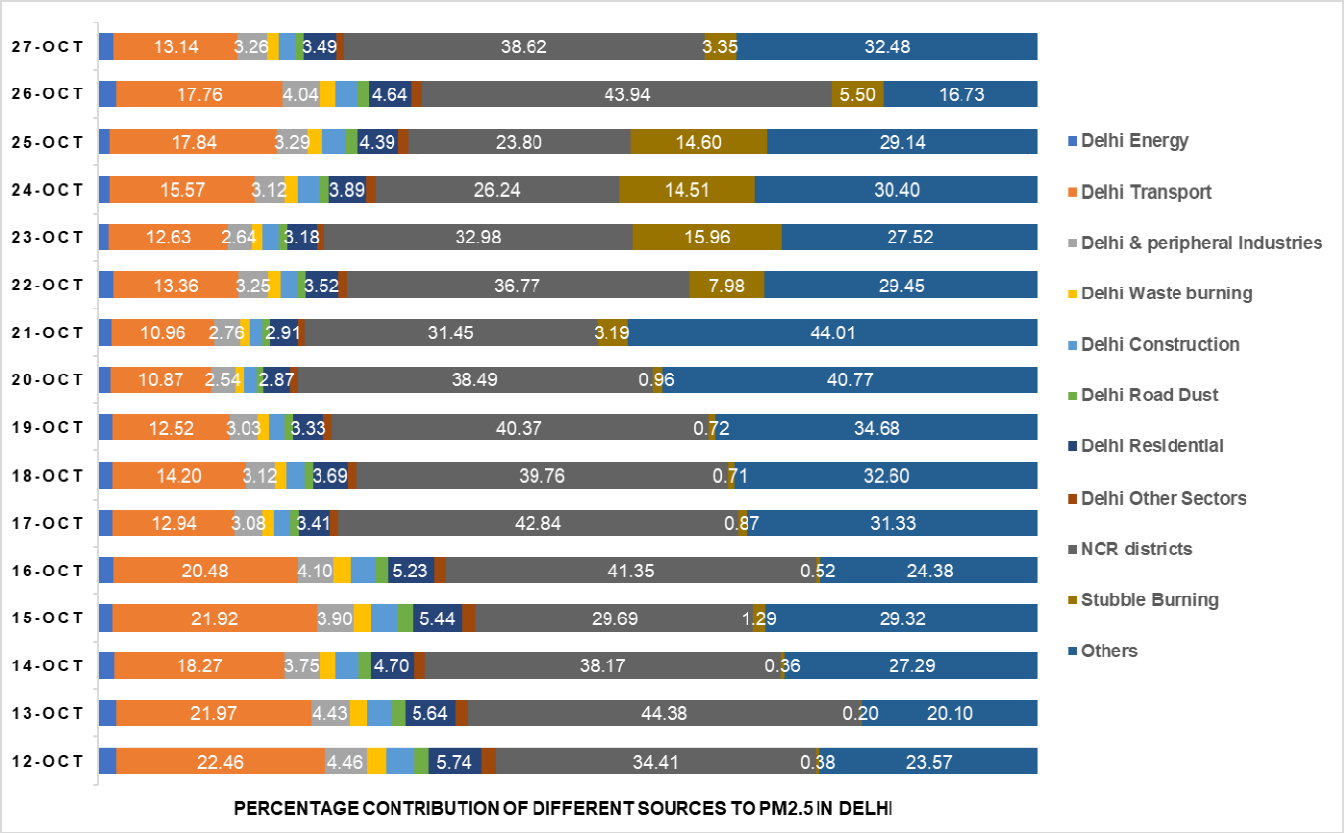


Source: CSE's analysis based on Decision Support System for Air Quality Management in Delhi of IITM

Note: 1) Data 13, 16 and 20 October was missing. Data for these dates were estimated based on the forecast available

Vehicles are the highest contributor among the local air pollution sources in Delhi: When only the local sources of air pollution in Delhi are assessed, (and contributions from outside sources are excluded), the transport sector contributes is more than half of the pollution coming from only the local sources. This is followed by residential burning, which is at 13 per cent, followed by industry at 11 per cent, construction- at 7 per cent, energy- at 6 per cent, waste burning- at 5 per cent, road dust and others at 4 per cent each. (see*Graph 4: Average fractional contribution of various sources of pollution to PM2.5 in Delhi (October 12–27, 2024)*

Graph 4: Fractional contribution of various sources of pollution to PM2.5 in Delhi (October 12–27, 2024)



Source: CSE's analysis based on Decision Support System for Air Quality Management in Delhi of IITM

Note: 1) Data for October 13, 16 and 20 was missing. Data for these dates were estimated based on the forecast available

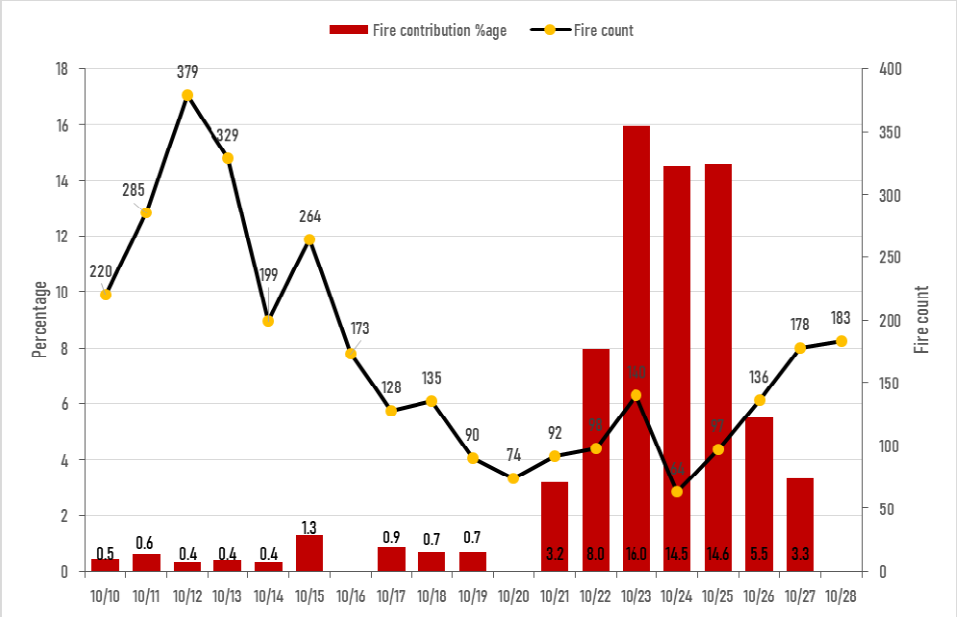
Lesser impact of farm fire on Delhi's Air Quality: So farthis year, farm fires have had a minimal impact on Delhi's air quality, with their contribution to PM2.5 levels remaining below 1 per cent until October 20, despite relative increase in fire counts during the period. As October progressed, there was a noticeable increase in fire count, peaking between October 22 and October 25. (See *Graph 5: Daily trend of farm stubble fire smoke's contribution to PM2.5 level in Delhi*).

During this period, the contribution of farm fires to Delhi's PM2.5 levels rose, reaching a peak of approximately 16 per cent on October 23. However, this influence quickly subsided, dropping to 3 per cent by October 27. This has happening due to changing wind directions from north-westerly during the days leading to higher contributions from stubble burning between October 21 and 25. This direction has again changed to south-easterly, leading to lesser contributions of stubble burning to Delhi's PM2.5 levels.

Between 10 October and 28 October, 3264 burning events were detected in the four states, which are distributed as 1870, 843, 539, and 12 in Punjab, UP, Haryana, and Delhi, respectively. (See Graph 6: Daily trend of farm stubble fires in Punjab, Haryana, Uttar Pradesh, and Delhi.)

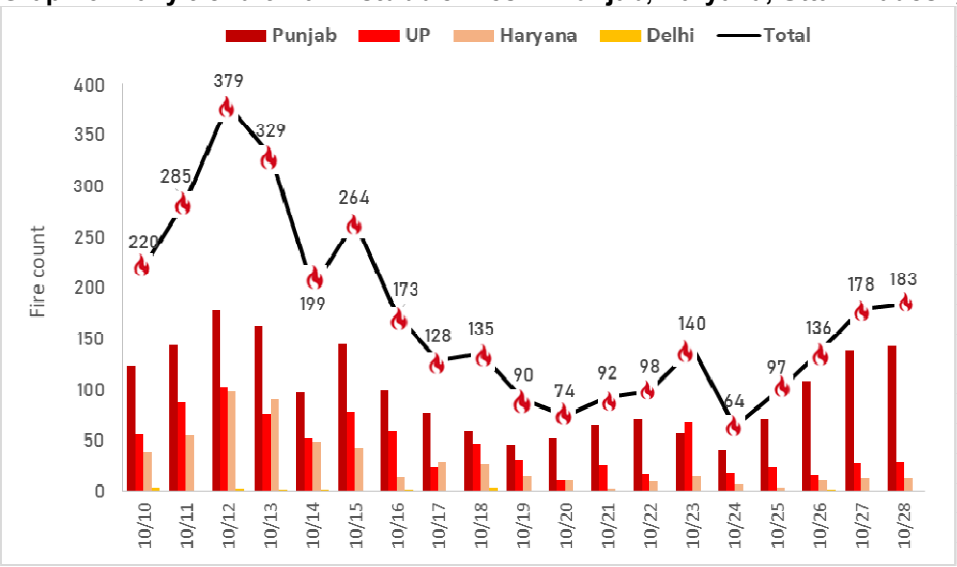
Unlike previous years, the smoke from the farm stubble fires has not overwhelmed the region's air quality yet.

Graph 5: Daily trend of farm stubble fire smoke's contribution to PM2.5 level in Delhi



Note: Farm stubble fire smoke contribution to Delhi's PM2.5 level is based on the SAFAR India publication and Farm stubble fire count data is based on the IARI data. Data from October 10- 28, 2024.
Source: CSE analysis based on the IARI and SAFAR data.

Graph 6: Daily trend of farm stubble fires in Punjab, Haryana, Uttar Pradesh, and Delhi



Note: Farm stubble fire count data is based on the IARI data. Data from 10 October to 28 October 2024.
Source: CSE analysis based on the IARI data.

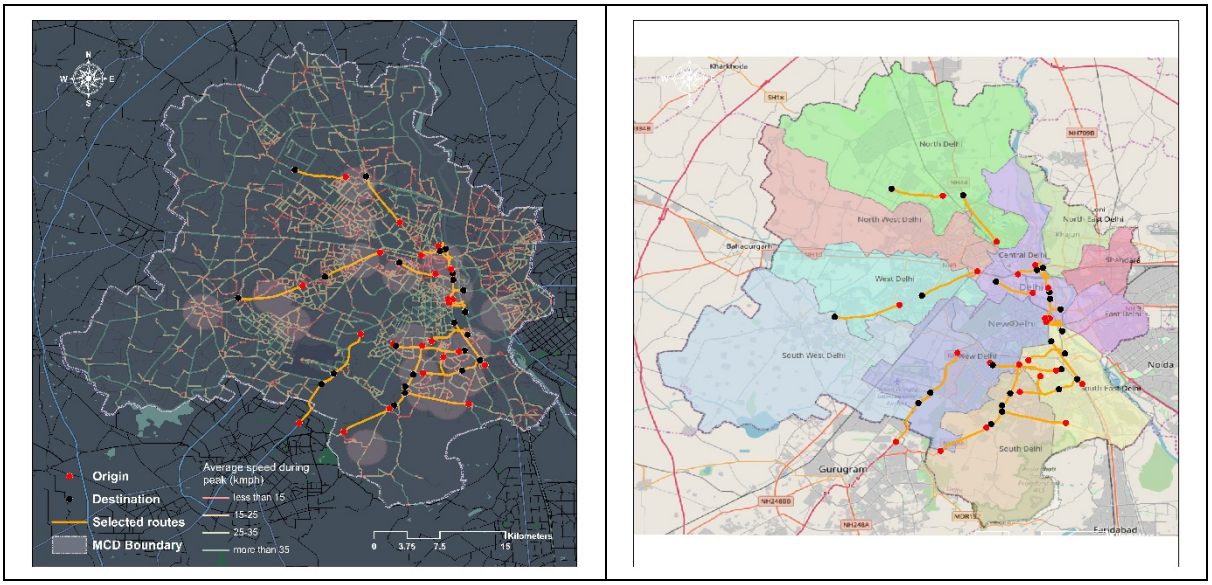
High traffic build up before Diwali worsens congestion and pollution impacts:
CSE has analysed hourly travel time data for 25 road stretches in Delhi for a period of 45 days (15th September to 29th October) provided by a popular web navigation and transportation service, Google Maps API, to analyse the Speed Reduction Congestion Index in Delhi. The Speed Reduction Index measures the reduction in speed on congested roads compared to free-flowing traffic conditions, and is directly proportional to the Congestion Index in the region.

The goal was to understand variations in traffic flow captured during peak and off-peak hours, gaining insights into how congestion evolves throughout the day. Further it was analysed how congestion is impacted by major festivals.

The road stretches studied were chosen after consulting several sources of literature available on the most congested areas in Delhi. Among these, the latest and most frequently referenced were the “Report of High-Powered Committee on Decongesting Traffic in Delhi” made publicly available in 2021 and the Delhi Traffic Police report on congestion hotspot identification in 2023 (see Map 1; Table 1).

The study was conducted by choosing the most congested samples based on literature, irrespective of an equal share of routes studied in each zone. The resultant geographical distribution and expanse for the routes is as follows: out of the 25 road stretches, 9 fall under Central Delhi Zone, 2 fall in each the North Zone and the West Zone, 6 fall in South Delhi Zone, 5 in the South-East Zone and 3 in the New Delhi Zone (includes the cantonment area).

Map 1: Selected routes in Delhi for congestion data collection; Spread of selected routes on Delhi zones map



Source: Prepared by CSE

Table 1: Selected routes for congestion analysis, Delhi

Route Number	Road Name	Towards direction	KM	Short Link
Route 1	Baba Banda Singh Bahadur Setu	Sarai Kale Khan	4.4	https://maps.app.goo.gl/PDAzJX3KsrQUbZ9J9
Route 2	Jangpura Rd	Delhi Golf Club	5.8	https://maps.app.goo.gl/hPx3tC4M3gubyrjaA
Route 3	Mahatma Gandhi Rd	Ashram	7.5	https://maps.app.goo.gl/vm3xxqf4NRXVmc568
Route 4	Mahatma Gandhi Rd	Moti Bagh	6.4	https://maps.app.goo.gl/CeAEi44vFNpBWp7W9
Route 5	Sri Aurobindo Marg	Mehrauli	5.1	https://maps.app.goo.gl/HJMAjfiAfVE9qwv69
Route 6	Outer Ring Rd	Okhla	6.5	https://maps.app.goo.gl/D12gjR5DyjN3V6VN7

Route 7	Outer Ring Rd	Greater Kailash to KakajiMandir	4.0	https://maps.app.goo.gl/W8eQwdFmzzXpV6ry8
Route 8	Acharya Shree Tulsi Marg	QutabMinar	6.0	https://maps.app.goo.gl/7S9r2FFZje9Pni5o6
Route 9	Acharya Shree Tulsi Marg	Hauz Khas	5.0	https://maps.app.goo.gl/XyZW1AErrf2UowRj9
Route 10	Delhi Ajmer Expressway	Gurugram to Delhi I.G.I. Airport	7.0	https://maps.app.goo.gl/bvja6PiByUpmxRvz5
Route 11	Delhi Ajmer Expressway	DhaulaKuan to Delhi I.G.I. Airport	7.5	https://maps.app.goo.gl/rCyHo82VtbhopuuBA
Route 12	Vikas Marg	ITO	2.1	https://maps.app.goo.gl/s1rXvzdpdPnrm5M86
Route 13	India Gate Circle (C Hexagon) - Purana Qila Rd	Pragati Maidan	2.1	https://maps.app.goo.gl/jhnVoDZH9UWUsmZYA
Route 14	Pragati Maidan Tunnel Rd	Sant Nagar	2.7	https://maps.app.goo.gl/DTf7iZiZSKkCTUcJ7
Route 15	Mathura Rd - Bhairon Marg	Supreme Court to Sant Nagar	2.8	https://maps.app.goo.gl/mFGxhGQtzcQHvFas6
Route 16	GT Karnal Rd	Shastri Park	2.8	https://maps.app.goo.gl/LB2KivqEqQxDrvFk9
Route 17	Lothian Rd - Netaji Subash Marg	Delhi Gate	5.9	https://maps.app.goo.gl/ns7Fib9v1p6qzGY3A
Route 18	DeshBandhu Gupta Rd	Sarai Rohilla Station	4.0	https://maps.app.goo.gl/eBHD7uDNbPVNZvuu7
Route 19	Lothian Rd - Netaji Subash Marg	Jama Masjid	2.5	https://maps.app.goo.gl/5rP8NRTc1T9G7eVM8
Route 20	Bahadur Shah Zafar Marg	Delhi Gate	2.4	https://maps.app.goo.gl/55BNdAbvZnADWXu37
Route 21	Shivaji Marg	Najafgarh	6.8	https://maps.app.goo.gl/TMZu4Ei5MUUzb1f7A
Route 22	Shivaji Marg	Subhash Nagar Metro	6.2	https://maps.app.goo.gl/dHRL62CffJqFRJqt9
Route 23	SamaypurBadli Metro Rd	Rohini	5.4	https://maps.app.goo.gl/zKXvYGUPQLc5M46q9
Route 24	GT Karnal Rd	LibasPur	6.3	https://maps.app.goo.gl/GK1e7Y1LSz6Ua6yD9
Route 25	MehrauliBadarpur Rd	Lado Sarai	6.6	https://maps.app.goo.gl/v5Tx4D5jgnP4JKHT7

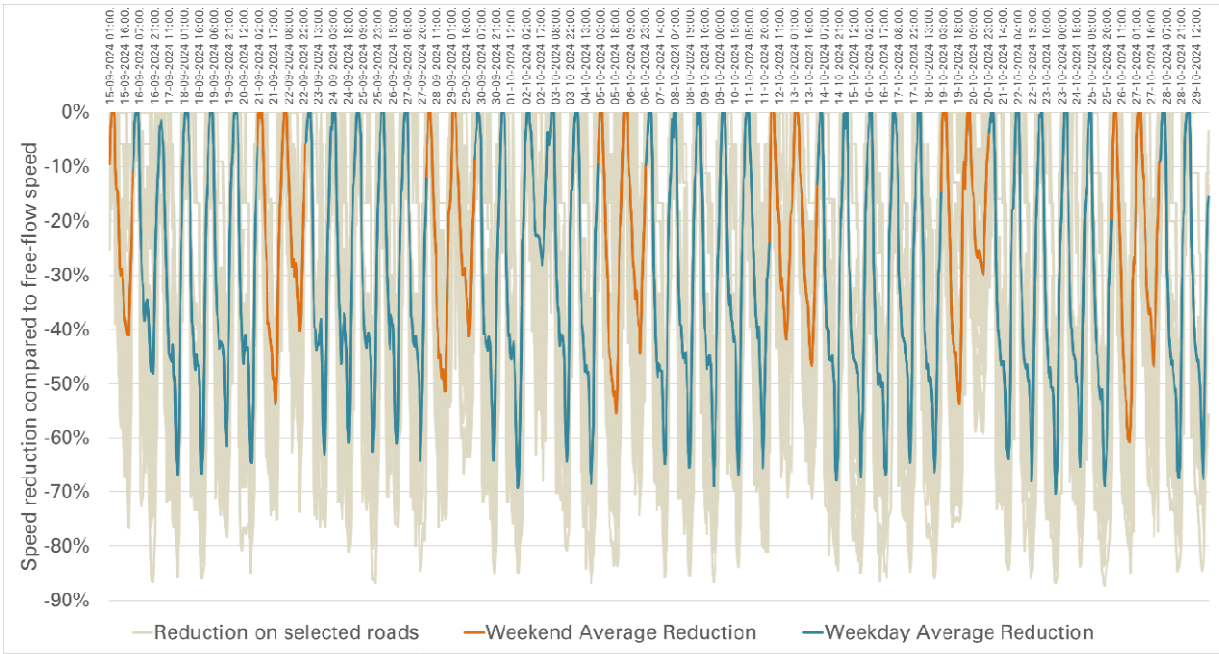
Prepared by CSE

The results are recorded to show variations in four timeframes: 1) Entire period of 45 days (15th September to 29th October), 2) A Regular Week (chosen as 23rd September to 29th September) 3) Durga Puja Week (5th October to 12th October), and finally the Diwali Week which is currently ongoing (26th October to 29th October).

Substantial build-up of congestion: During the entire period under scrutiny, an average speed reduction of 40.8 per cent in weekday morning peaks is observed and a 57.9 per cent reduction during the evening peak is observed.

During weekends, a 27.6 per cent speed reduction occurs in the mornings, while 42 per cent reduction occurs during the evening (see Graph 7: Speed change during different times of day in Delhi, 15th September-29thOctobe*).*

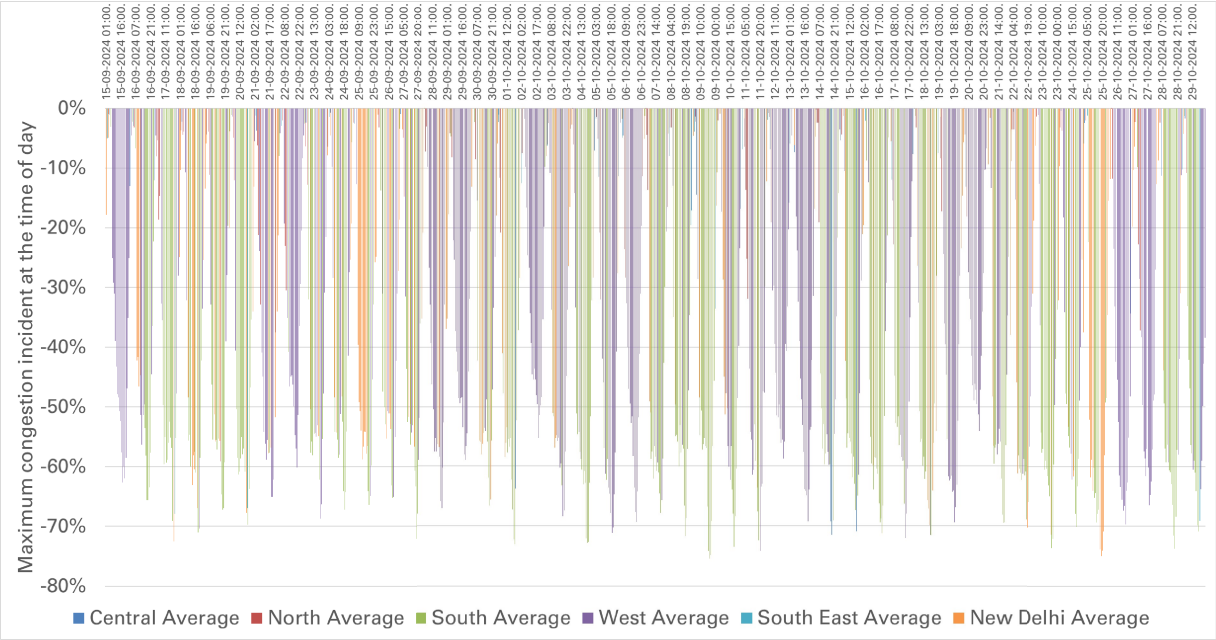
Graph 7: Speed change during different times of day in Delhi, 15th September-29thOctober



Prepared by CSE using Google Maps API

The routes were further divided geographically as per the Zone Boundaries in Delhi, to correlate vulnerability with zonal characteristics of vehicle ownership. For this, the number of instances of highest congestion index (highest reduction in speed) were recorded for any given time of day in the 45-day period. Geographically, the West and South Zones in Delhi are the most vulnerable, with 27 per cent and 30 per cent incidences of all highest congestion indices during the period (see Graph 2).

Graph 8: Location (zone) and intensity of highest incidences of congestion for respective times of day during the 45 day period



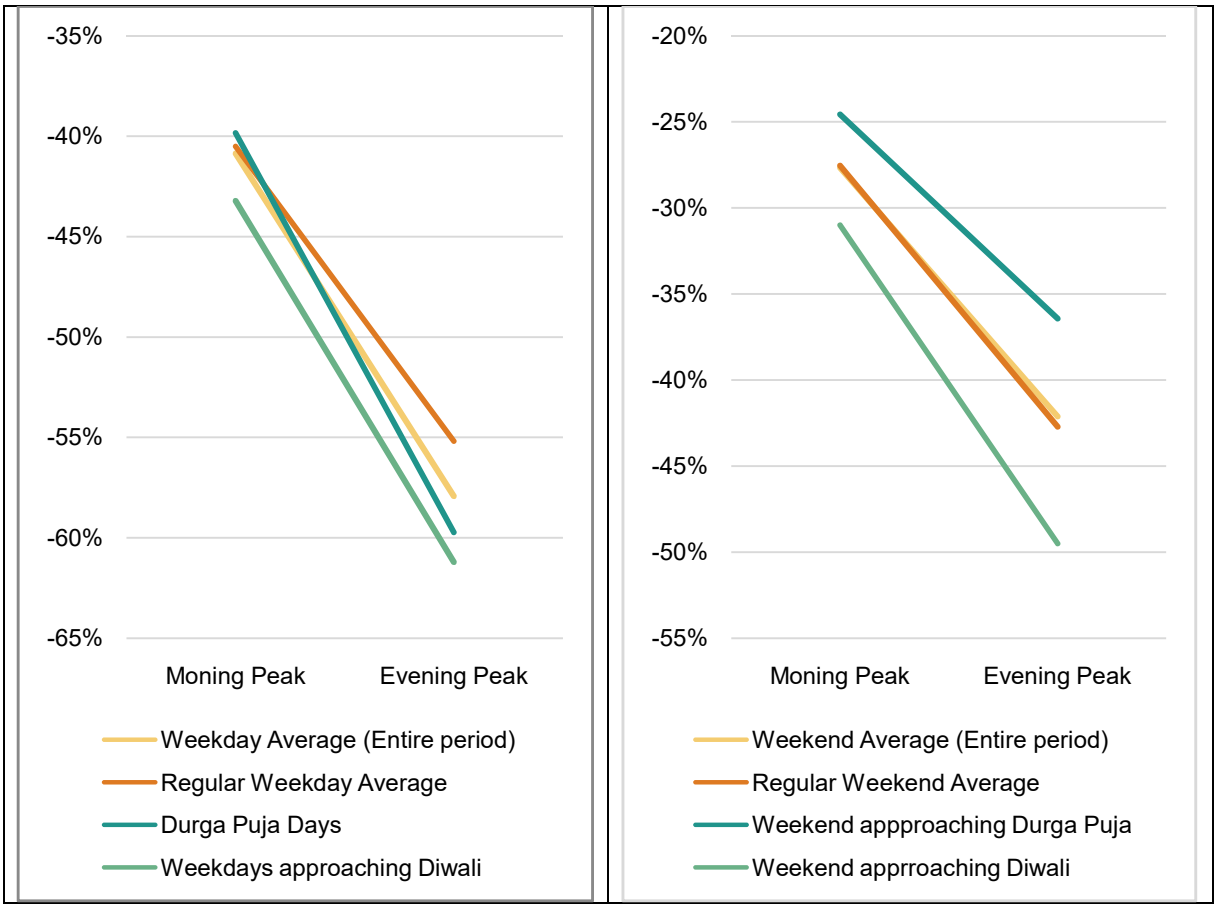
Prepared by CSE using Google Maps API

During the ongoing festival week preceding Diwali, the average increase in congestion during morning peaks on a weekday is 4 per cent, with some stretches suffering congestion index increase of 7-8 per cent. During evening peaks, the average increase was 7 per cent, with maximum increase recorded upto 15 per cent (see Graph 3).

The weekend approaching Diwali is by far the most congested weekend during the entire period. It is unusual to see an average speed reduction of more than 25 per cent during weekend mornings, however for the first time in the last month and a half the average reduction is more than 30 per cent (atleast 5 per cent higher congestion than a regular weekend), and on some stretches even crossed the 60 per cent speed reduction mark. Similarly, during weekend evenings that approached Diwali, a 7-10 per cent increase in congestion was observed (see Graph 3).

Graph 9: Average speed reduction during studied timeframes

(A) Weekday average speed reduction during studied timeframes	*(B) Weekend average speed reduction during studied timeframes*

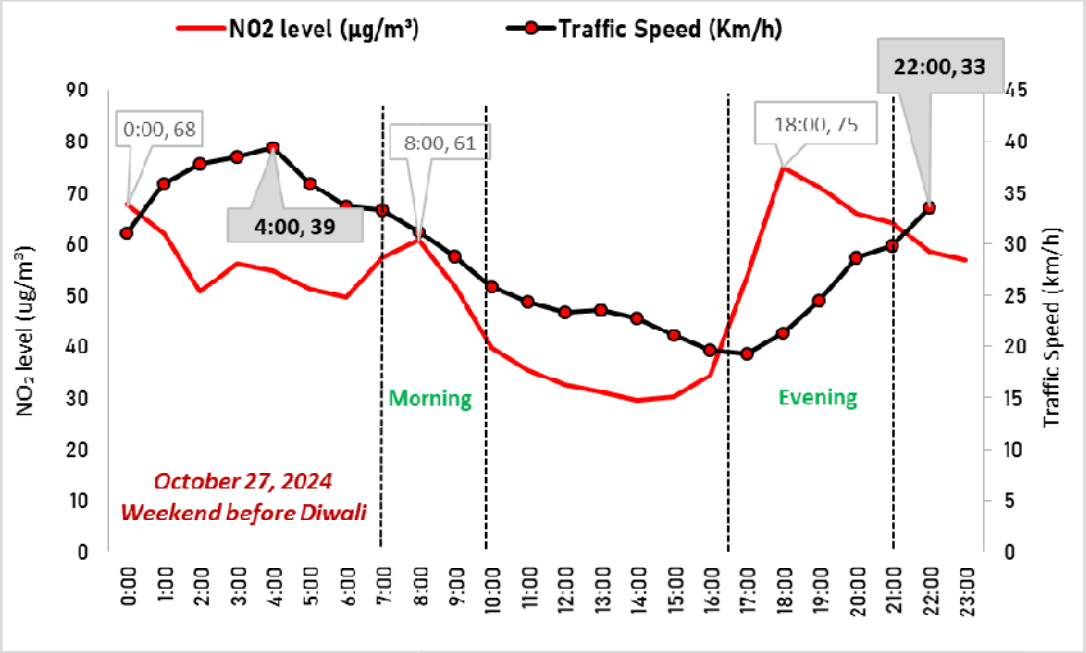


Prepared by CSE using Google Maps API data

Hourly nitrogen dioxide levels correlate well with congestion in the city: It is well known that vehicles caught in congestion and idling can spew emissions several times higher than their normal emissions on roads. Considering that the vehicles are the dominant sources of nitrogen oxide levels, there is a strong co-relation between vehicles and hourly changes in NOx levels. The daily accumulation of pollution is significantly affected by peak traffic hours. The hourly level of NO2 correlated with congestion levels though there have been dilution due to dispersion during the afternoon. Hourly NO2 levels during evenings could be high ranging between 54 µg/m³ to 75 µg/m³. This is the time when congestion is also high.

A comparison of traffic on specific days revealed that congestion was highest on the weekend before Diwali (October 27th). During this time, the hourly concentration of NO2 was notably elevated, peaking at 61 µg/m³ in the morning when traffic speed averaged 31 km/h, and reaching 75 µg/m³ in the evening with a reduced traffic speed of 21 km/h. Notably, even at midnight, the concentration of NO2 remained elevated at 68 µg/m³. (*See Graph 10: Correlation between NO2 and traffic speed from 12 AM to 12 PM)*

Graph 10: Correlation between NO2 and traffic speed during 12 am- 12 pm (27th Oct, 2024)



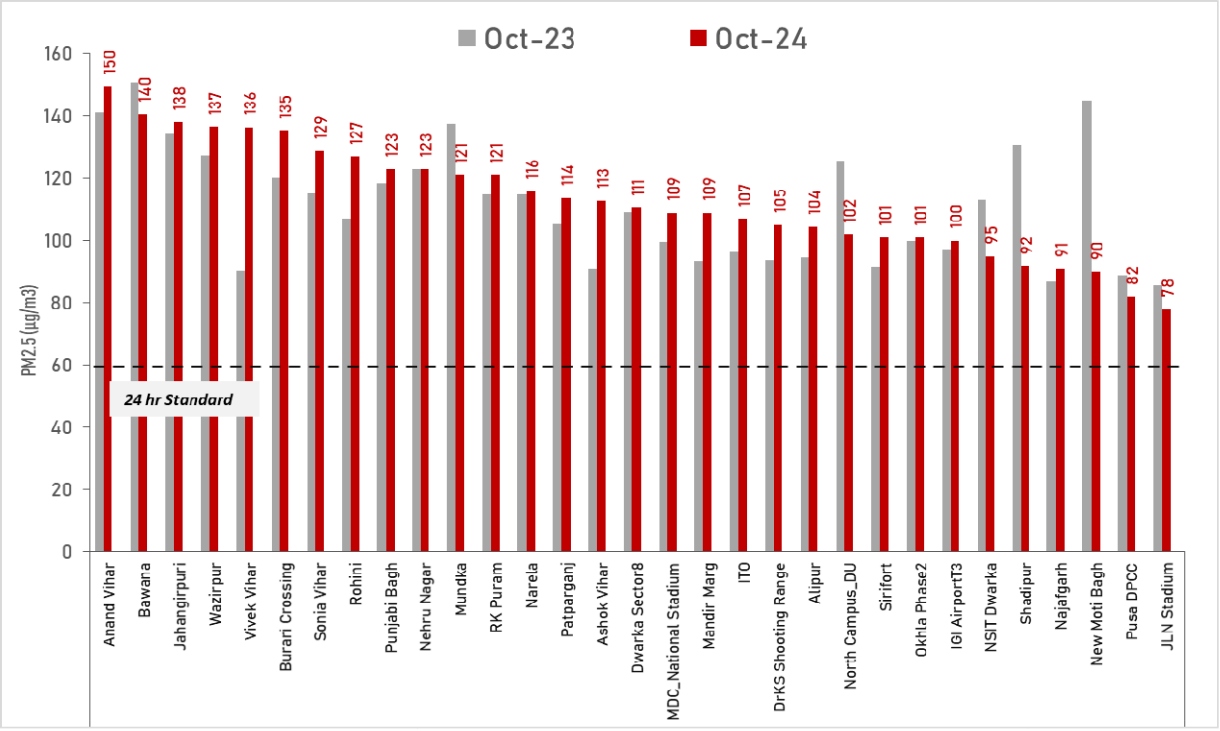
Source: CSE analysis of CPCB's real-time air quality data and traffic data from Google map

Hotspots continue to remain problematic:

All 13 official air pollution hotspots in Delhi have shown a rise in PM2.5 levels this October compared to the same period in 2023, except Mundka and Bawana, which demonstrated improvements of 12 per cent and 7 per cent respectively in PM2.5 concentrations. Despite this progress, Bawana remains a major concern, recording the second-highest PM2.5 levels in the past week (Oct 21 – Oct 28) with an average of 201 µg/m³. Burari Crossing led the list, averaging the highest PM2.5 concentration at 204 µg/m³, followed closely by Bawana and Jahangirpuri, both at 201 µg/m³. All official hotspots have remained above the critical threshold of 100 µg/m³ *(See Graph 11: Station-wise average of PM2.5 for October month in 2023 and 2024 in Delhi).*

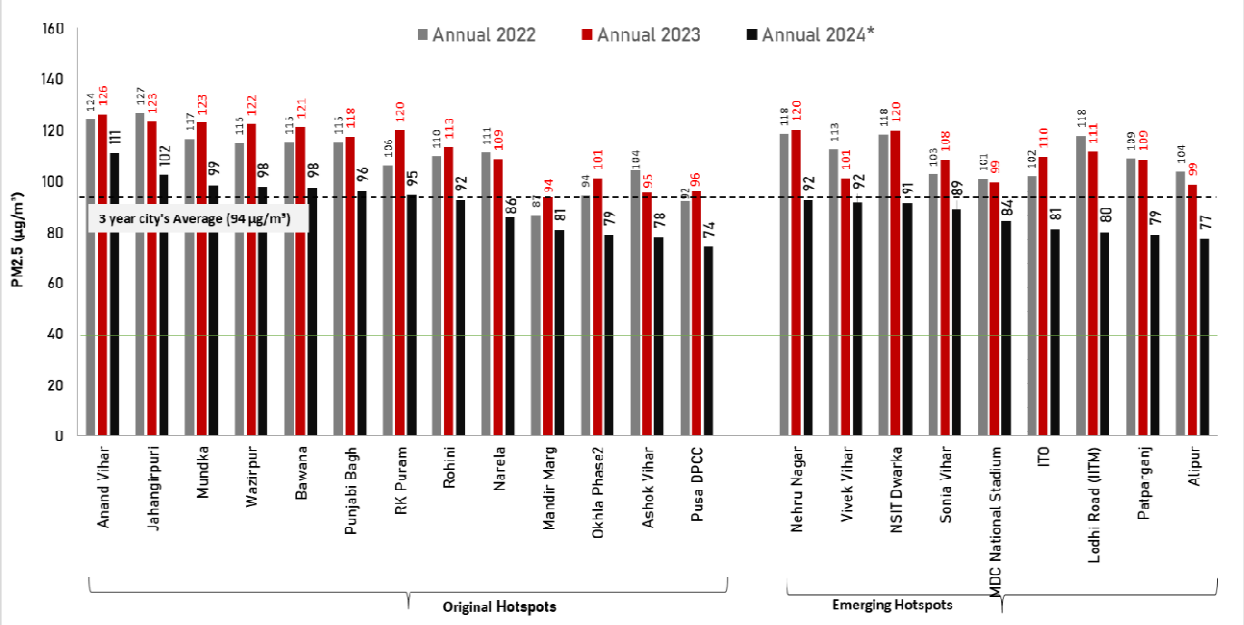
On an annual average, AnandVihar ranks as Delhi's most polluted hotspot in 2024, with a PM2.5 level of 111 µg/m³, followed by Jahangirpuri at 102 µg/m³. Nehru Nagar and VivekVihar have emerged as new pollution hotspots, each averaging 92 µg/m³ in PM2.5 concentration. (See *Graph 12: Trend in annual average PM2.5 level among the official and emerging hotspots of Delhi*).

Graph 11: Station-wise average of PM2.5 for October month in 2023 and 2024 in Delhi



Note: October average $PM_{2.5}$ concentration is based on the mean of daily values recorded at the CAAQM stations given it has adequate data. Data till 28 Oct, 2024*.
Source: CSE analysis of CPCB's real-time air quality data

Graph 12: Trend in annual average PM2.5 level among the official and emerging hotspots of Delhi



Note: Average $PM_{2.5}$ concentration is based on the mean of daily values recorded at the CAAQM stations given it has adequate data. Data till 28 Oct, 2024*.
Source: CSE analysis of CPCB's real-time air quality data

Take away

This time the seasonal surge in PM25 levels during the early phase of winter in Delhi is not hugely impacted by the farm fires that have begun to decline. But the impact of the local sources of air pollution in Delhi and the surrounding regions dominates and is much bigger.

Among the local sources, contribution of the vehicular emissions to daily PM2.5 levels is maximum followed by residential solid fuel burning and industrial sources. This is evident from the official estimates of IITM.

It is clear, that while action on farm fire needs to get more aggressive and impactful to eliminate the problem, the seasonal episodic pollution cannot continue to mask and hide the significant contribution of local pollution sources and sources from the surrounding regions. Clean air benchmark cannot be met and sustained throughout the year without stringent and upscaled action targeting the key sources of pollution including vehicles, industry, solid fuels, waste burning, construction among others. This immediately requires action taken report to identify the key gaps in action and the strategy to address this.

- The clean air action in Delhi and NCR requires massive upscaling of local and regional action to curb emissions from vehicles to increase the usage an share of integrated public transport services, walking, cycling and restraintmeasures to reduce usage of personal vehicles. This needs to be supported by upscaled and ambitious vehicle electrification strategy.

- Initiate stronger action to reduce/eliminate use of solid fuels, take stronger steps to scale up clean fuel transition and emissions control from industries including peripheral industries and those in non-conforming areas, and ensure clean construction and elimination of garbage burning.