

Winter pollution crisis in megacities of India: Going beyond Delhi

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The mega cities of India – Delhi, Mumbai, Kolkata, Bengaluru, Hyderabad, and Chennai, -- irrespective of their diverse geographic and climatic context, have experienced worsening of PM_{2.5} levels during the winter of 2024-25 (October 1, 2024-January 31, 2025). The overall level and peaking of pollution levels have however varied across cities depending on the meteorological conditions of different climatic zones.

While Delhi located in the land locked Indo-Gangetic Plain (IGP) with adverse meteorology, have recorded the highest level of pollution during winter, Kolkata - also at the tip of the IGP, ranked second among the mega cities. The megacities outside the IGP including Mumbai, Chennai, Hyderabad, and Bengaluru, and Chennai despite having more advantageous climatic conditions and natural ventilation, have also experienced increase in the average PM_{2.5} concentrations.

Even though other than Delhi and Chennai, all other mega cities have recorded city-wide winter average that is comparatively lower than the average of the past three winters, the concentration across different locations have been high leading to high exposures across the cities.

This trend has emerged from the new analysis of real time PM_{2.5} data in Delhi, Kolkata, Mumbai, Hyderabad, Bengaluru and Chennai during the winter period by the Centre for Science and Environment (CSE). This has evaluated pollution trends in peer megacities, provided insights into long-term seasonal variations and annual shifts in particulate pollution during winter.

The peaking of pollution during winter in any climatic zone is the sign of underlying problem of persistent air pollution in these rapidly urbanizing and motorizing cities. The growing impact of local sources of pollution shows up in the pollution hotspots across these cities increasing local exposures and risks, These cities need very stringent action to curb pollution from all sources to meet the clean air standards. But cities like Delhi and Kolkata that face an additional challenge of adverse meteorology that enhance the concentration, need even more stringent action to counter these effects.

While Delhi's winter air quality often dominates public discourse, rising pollution levels in other megacities remain largely overlooked. Despite some improvement in seasonal pollution trends, winter pollution continues to remain high or is rising locally.

The methodology: This is an assessment of annual and seasonal trends in PM_{2.5} concentrations for the period October 1 to January 31 the years 2021-22, 2022-23, 2023-24, and 2024-25. This analysis is based on real time data available from currently working air quality monitoring stations in Delhi, Kolkata, Mumbai, Chennai, Hyderabad and Bengaluru. A huge volume of data points has been cleaned and data gaps addressed based on the USEPA method for this analysis. This analysis covers 115 continuous ambient air quality monitoring stations (CAAQMS) spread across the cities. Delhi (40), Kolkata (7), Mumbai (31), Hyderabad (14), Bengaluru (14), and Chennai (9) have more than one real-time station, therefore citywide average is used for comparative analysis and it is defined as average of all city stations that have been functional for the defined study period.

The key highlights

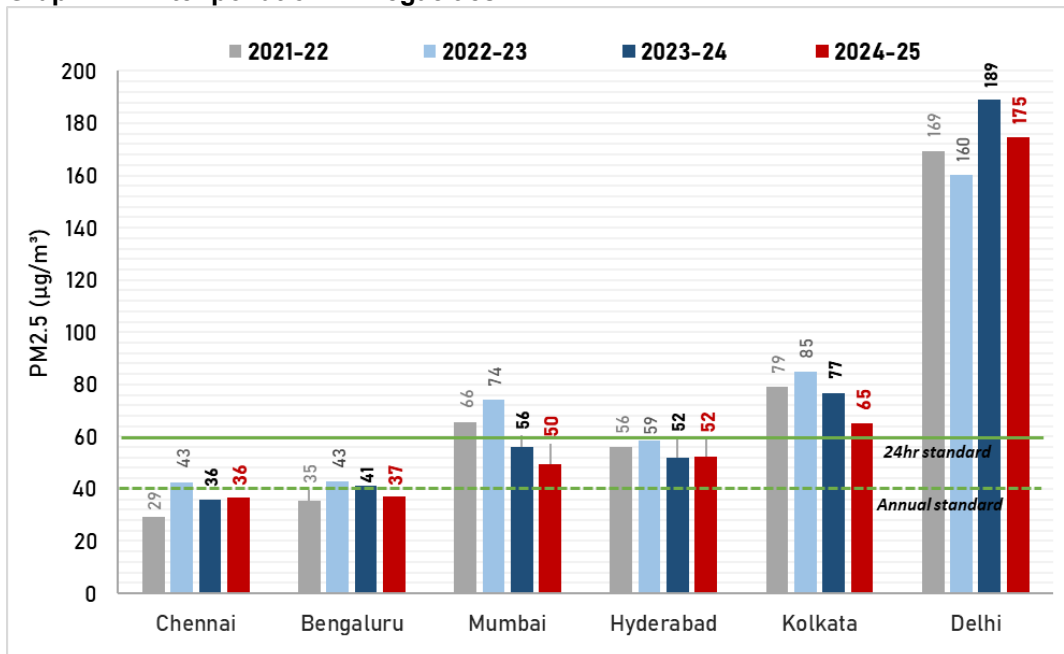
During this winter, Kolkata and Hyderabad were most polluted after Delhi, while Mumbai, Chennai and Bengaluru saw the fastest worsening of localized pollution levels: Delhi with winter average PM_{2.5} of 175 µg/m³ remains the most polluted megacity by a large margin during winter, but the winter average has shown improvement over the previous winter. In other five megacities, the average winter PM_{2.5} level was 65 µg/m³ in Kolkata and 52 µg/m³ in Hyderabad. The level in Mumbai was 50 µg/m³. In Chennai and Bengaluru, the winter

levels were $36 \mu\text{g}/\text{m}^3$ and $37 \mu\text{g}/\text{m}^3$ respectively. The winter averages cannot be directly compared with 24-hour average or annual average. Indicatively, daily standards for PM_{2.5} are $60 \mu\text{g}/\text{m}^3$ and annual standards are $40 \mu\text{g}/\text{m}^3$. (Graph 1: Winter pollution in megacities).

-- However, there is a longer-term downward trend in winter averages in some mega cities. Compared to winter of 2021-22, Mumbai, Kolkata, and Hyderabad show improvement with their winter PM_{2.5} levels dropping by 16 per cent, 14 per cent and 16 per cent respectively. Delhi has recorded a 7 per cent reduction in pollution levels compared to the previous winter but 5 per cent higher than in 2021-22. Meanwhile, Bengaluru and Chennai have recorded an increase in PM_{2.5} levels compared to 2021-22, reflecting a worsening trend in air quality.

(See Graph 2: Change in winter PM_{2.5} level among megacities compared to mean of previous three winters).

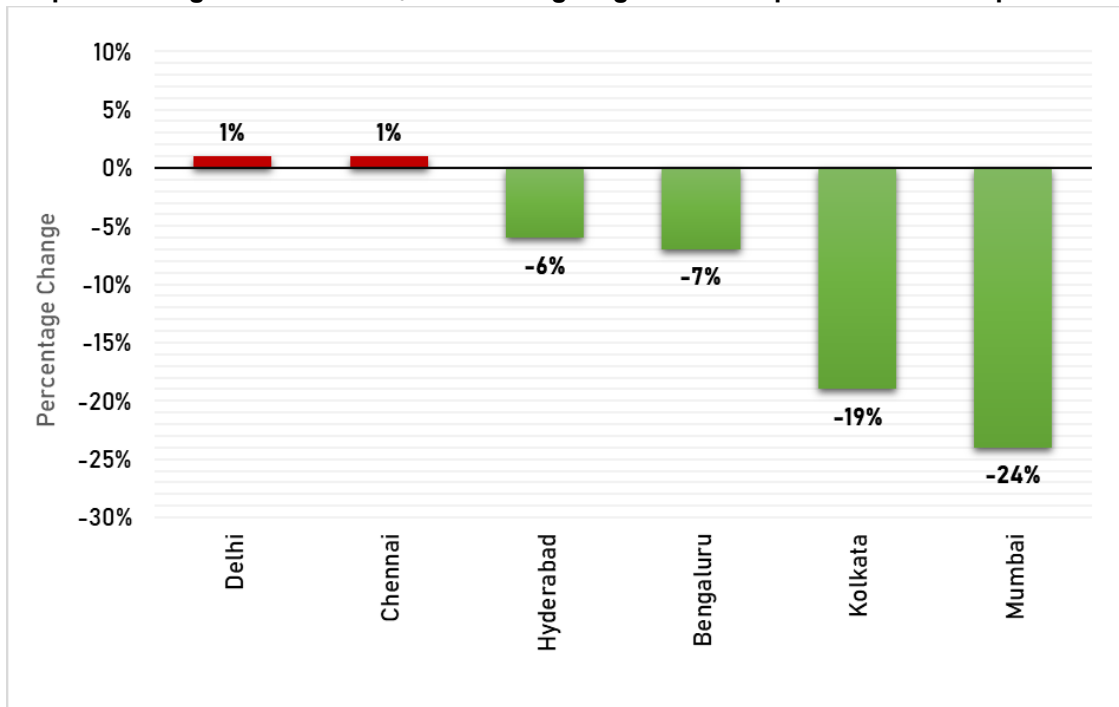
Graph 1: Winter pollution in megacities



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

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

Graph 2: Change in winter PM_{2.5} level among megacities compared to mean of previous three winters



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

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

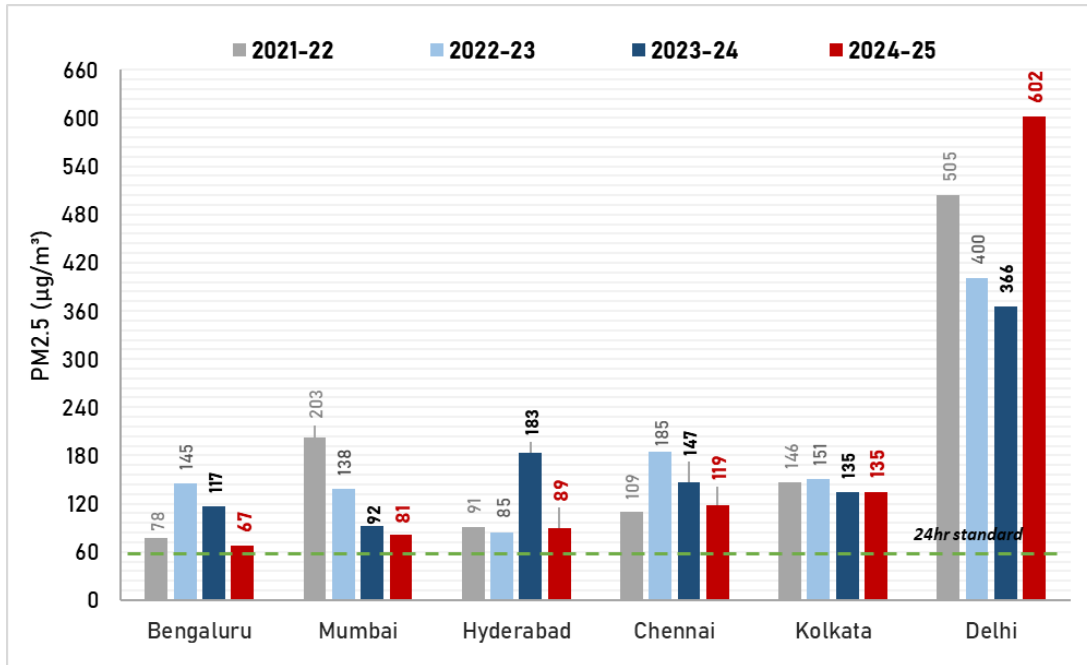
Peak winter pollution in Delhi hits worst level in last four years: Delhi recorded its highest daily PM_{2.5} level in four years, with pollution spiking to 602 µg/m³ on November 18, 2024—the highest 24-hour average since 2021. This marks a 65 per cent increase from last winter’s peak and 42 per cent higher than Delhi’s three-year average, highlighting a worsening pollution trend in the capital.

Kolkata and Chennai showed little improvement, with Kolkata’s PM_{2.5} stagnating at 135 µg/m³, while Chennai saw a slight reduction from 147 µg/m³ last winter to 119 µg/m³ this year. In contrast, Hyderabad, Mumbai, and Bengaluru recorded notable reductions in pollution levels. Hyderabad showed the most improvement, with a 51 per cent drop in PM_{2.5}, bringing levels down to 89 µg/m³ from 183 µg/m³ last year. Bengaluru followed with a 42 per cent decline, reducing levels to 67 µg/m³, while Chennai saw a 19 per cent improvement and Mumbai recorded a 12 per cent drop, lowering its PM_{2.5} from 92 µg/m³ to 81 µg/m³.

This winter’s peak daily pollution levels in Kolkata, Chennai, and Hyderabad were lower than their previous winter peaks, but still fell under the "poor" AQI category. (See *Graph 3: Winter peak pollution levels in megacities*). Kolkata’s winter peak stood at 135 µg/m³ registered on 2 November 2024, for Chennai it stood at 119 µg/m³ registered on 31 October 2024, and for Hyderabad it stood at 89 µg/m³ registered on 25 November 2024.

When compared to the three-year average, Delhi remains the worst performer, with pollution levels continuing to rise, while other megacities have shown sustained improvement. Despite these reductions, winter air pollution remains a major concern, with cities still exceeding safe air quality limits. (See *Graph 4: Change in winter PM_{2.5} peak level among megacities compared to mean of previous three winters*).

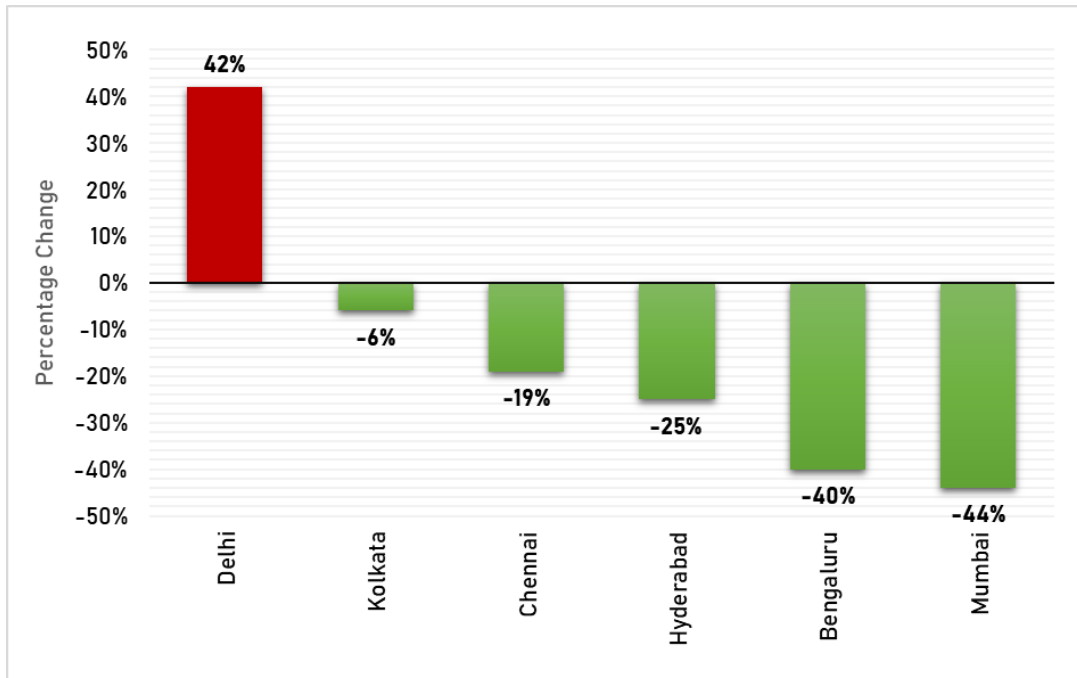
Graph 3: Winter peak pollution levels in megacities



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

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

Graph 4: Change in winter PM2.5 peak level among megacities compared to mean of previous three winters



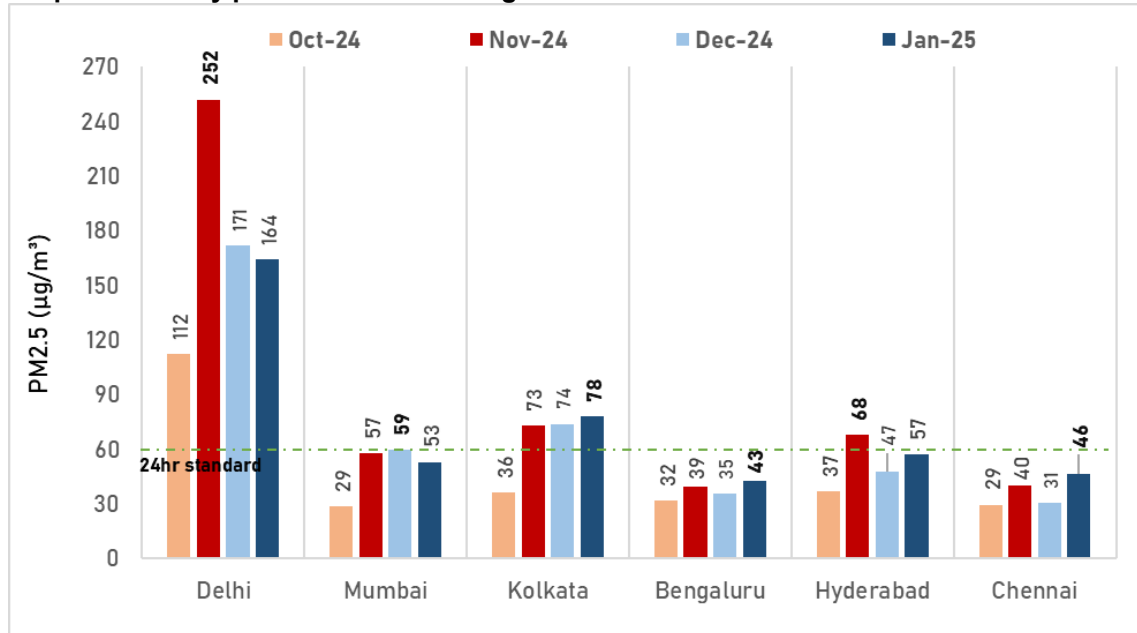
Note: Average PM_{2.5} concentration is based on mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter.

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

Monthly air quality pattern varies across the megacities: Air pollution trends differ across India's megacities, with Delhi and Hyderabad experiencing their worst air quality in November, while other cities saw peak pollution in December and January.

January emerged as the most polluted month for Kolkata, Bengaluru, and Chennai, with air quality deteriorating further compared to previous months. Mumbai, on the other hand, recorded its worst pollution levels in December (See *Graph 5: Monthly pollution levels in megacities*). Kolkata was most polluted megacity (excluding Delhi) for months of November, December and January.

Graph 5: Monthly pollution levels in megacities

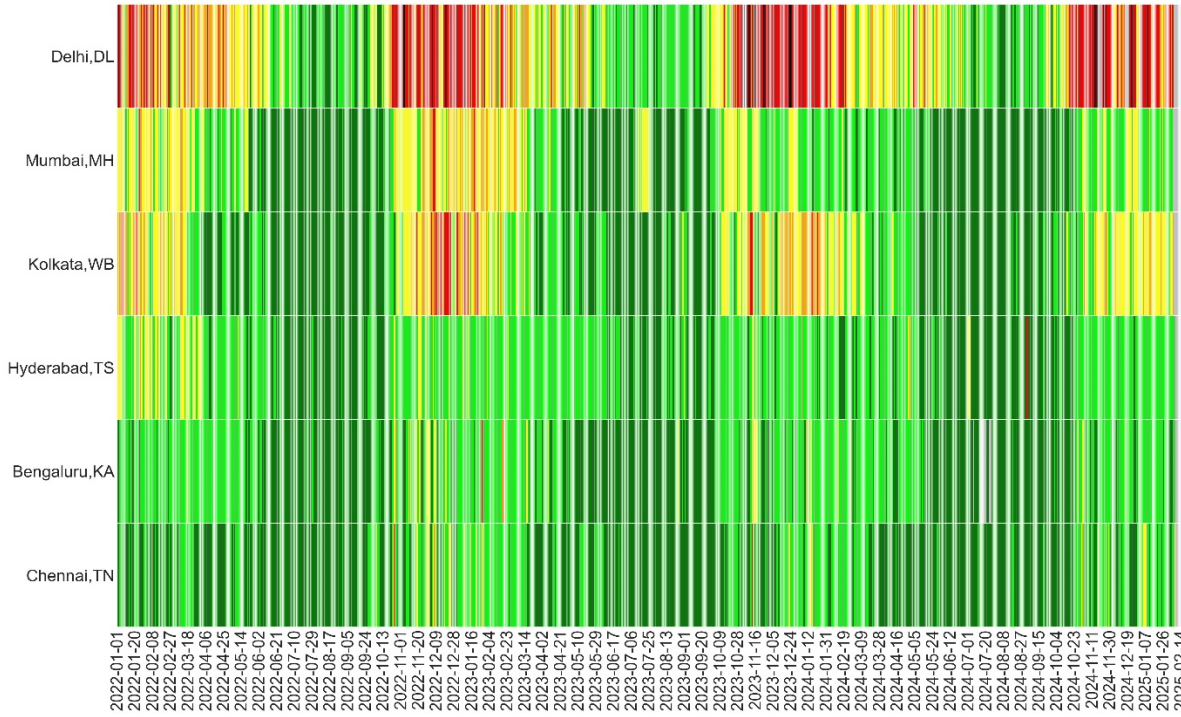


Note: Average PM_{2.5} concentration is based on mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter.

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

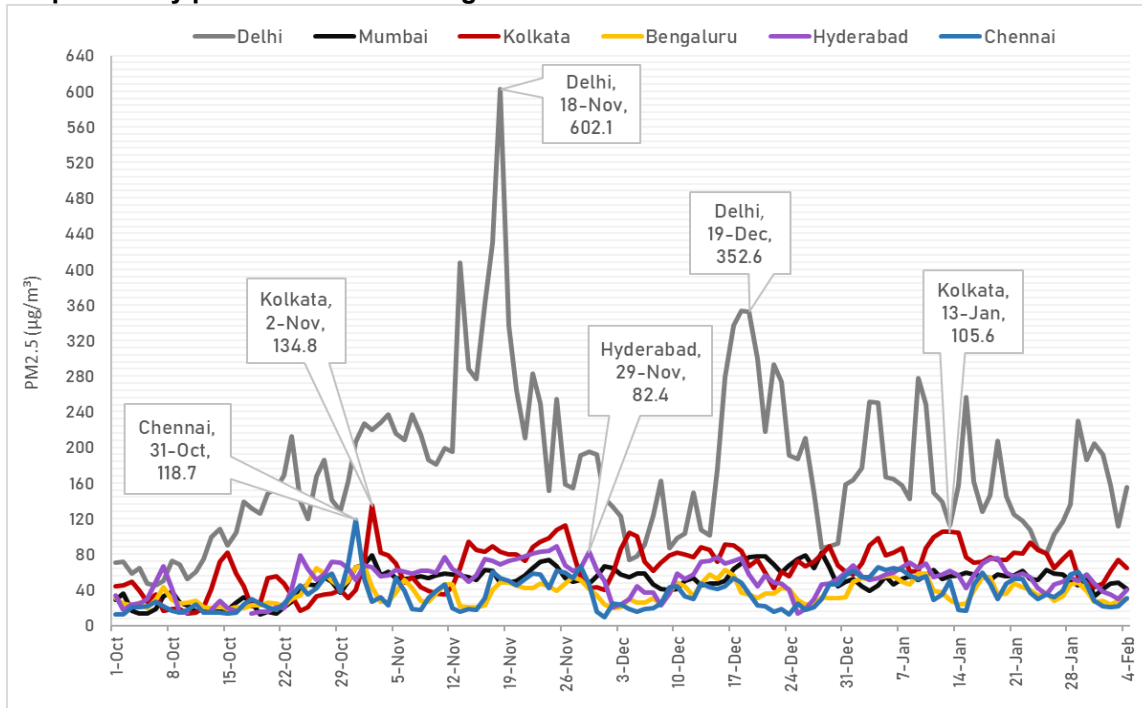
Winter is problematic season for all megacities but intensity of the problem varies: The days with bad air quality occurred in clusters during the winter season in the megacities. The clustering of bad air days was longer in Delhi, Kolkata, and Mumbai but of shorter duration in Hyderabad, Bengaluru and Chennai (See *Graph 6: PM2.5 calendar for megacities*). Intensity and duration of these bad air days was long enough in Delhi to get classified as a smog episode (See *Graph 7: Daily pollution levels in megacities*).

Graph 6: PM_{2.5} calendar for megacities



Note: Average PM_{2.5} concentration is based on mean of daily values recorded at all CAAQM stations in the city that have adequate data for the winter. Cell colour is based on the official colour-scheme of AQI sub-categories. Blue loops mark smog episodes.
 Source: CSE analysis of CPCB's real time air quality data

Graph 7: Daily pollution levels in megacities



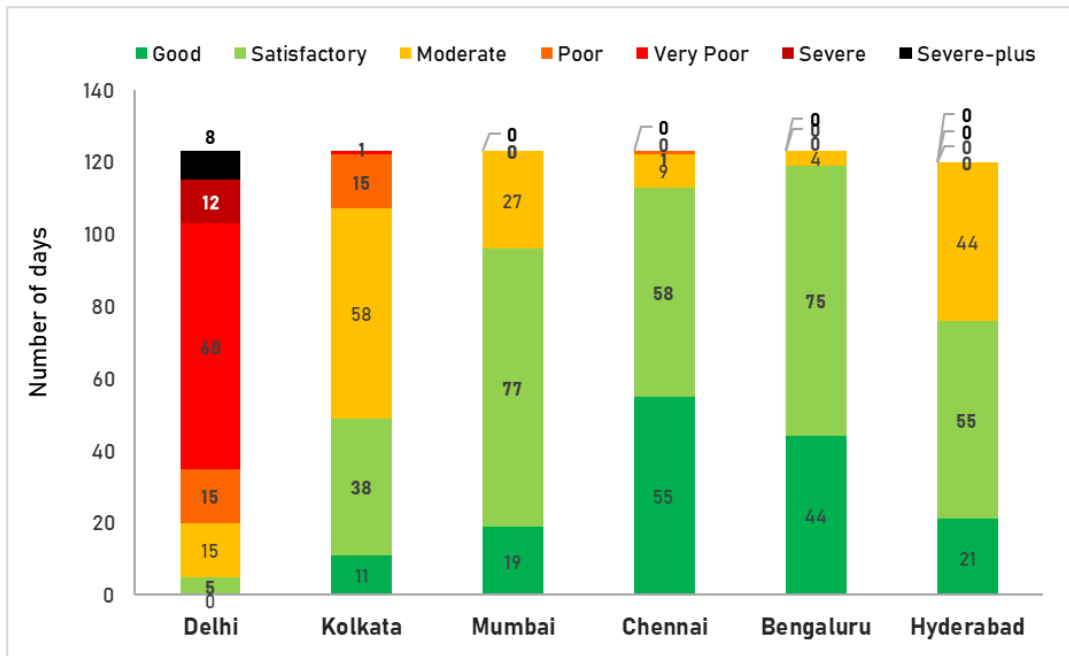
Note: Average PM_{2.5} concentration is based on mean of daily values recorded at all CAAQM stations in the city that have adequate data for the winter.
 Source: CSE analysis of CPCB's real time air quality data

Kolkata registers high number of 'poor' AQI days, Delhi remains the worst: Kolkata's long-term seasonal PM_{2.5} trend was lower, but it recorded the same number of 'poor' air quality days as Delhi this winter. With 15 days of 'poor' AQI, Kolkata matched Delhi's count and also experienced one day of 'very poor' AQI. Among the megacities, Chennai had only one day of 'poor' AQI, while Mumbai, Bengaluru, and Hyderabad recorded zero 'poor' AQI days. (See Graph 8: Distribution of AQI days for megacities).

In terms of cleaner air, Mumbai had only 19 days of 'good' AQI, followed by Kolkata with just 11—the lowest among megacities (excluding Delhi). In contrast, Hyderabad (21 days), Bengaluru (44 days), and Chennai (55 days) recorded the highest number of 'good' AQI days.

Delhi remained the most polluted megacity, registering 8 days of 'severe+' AQI, 12 days of 'severe' AQI, 68 days of 'very poor' AQI, and no 'good' AQI days this winter.

Graph 8: Distribution of AQI days for megacities (Oct- Jan)



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

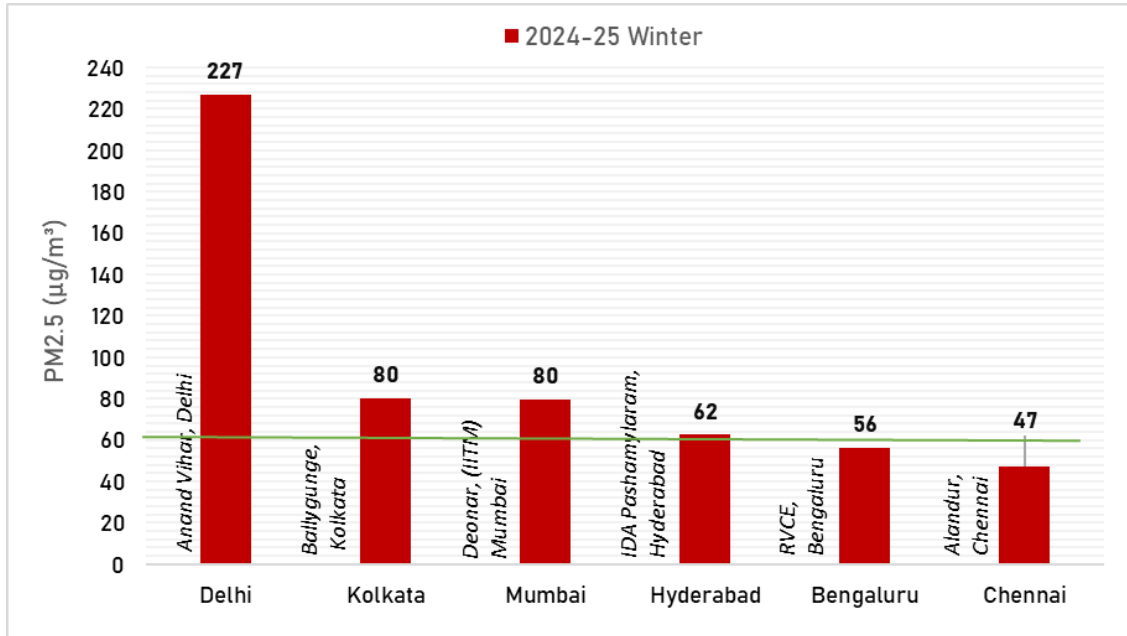
Source: CSE analysis of CPCB's real time air quality data

Worst affected locations within megacities have pollution levels 19 – 60 per cent higher than citywide average:

There is considerable variation in air quality among the locations of each megacity with worst locations being considerably more polluted than citywide average. In Kolkata and Mumbai, the worst air quality was recorded at Ballygunge and Deonar whose seasonal average stood at 80 µg/m³. Notably, four of the six most polluted locations among the 68 monitoring stations across five megacities were in Mumbai, while the remaining two were in Kolkata. IDA Pashamlaram was the most pollution location in Hyderabad with seasonal average of 62 µg/m³. In Bengaluru most polluted location was RVCE and its seasonal average was 56 µg/m³. Alandur was the most polluted location in Chennai with seasonal average of 47 µg/m³ (See Graph 9: Worst station within megacities & Annexure 1: October-January PM_{2.5} level at station levels)

When compared to the citywide average, pollution levels in the worst-affected locations within each megacity were significantly higher. Chennai saw a 30 per cent increase, while Bengaluru recorded a 51 per cent rise. Mumbai experienced the highest disparity, with pollution levels 60 per cent higher than the citywide average. In Hyderabad, the worst-affected location had 19 per cent higher pollution, whereas Kolkata and Delhi recorded increases of 23 per cent and 30 per cent, respectively.

Graph 9: Worst station within megacities



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

The way forward

Even after five years of the National Clean Air Programme the mega cities, despite investing substantial share of the grant from the XVth Finance Commission for clean air action, are still struggling to meet the clean air standards throughout the year and in all locations of the city to reduce toxic exposures.

The NCAP programme needs to be further strengthened to accelerate action to drastically cut emissions from vehicles, industry, power plants, waste streams, construction and use of solid fuels in households and dust sources to enable all cities to meet the clean air standards and increase the number of good air days.

At the same time, the cities that are located in the IGP are struggling harder due to very high local and regional pollution and adverse meteorological conditions, require significantly more upscaled and stringent action to counter the effect of adverse meteorology and climatic condition and the pollution impacts of the rapid urban growth and motorization.

Annexure 1: October-January PM2.5 level at station levels

	Station name	2024-25 winter PM2.5 level in µg/m ³
Mumbai citywide average		50
1	Deonar (IITM), Mumbai	80
2	Shivaji Nagar, Mumbai*	76
3	MaladW (IITM), Mumbai	74
4	Mazgaon (IITM), Mumbai	73
5	Sewri, Mumbai*	70
6	BorivaliE (IITM), Mumbai	69
7	Kandival West, Mumbai*	68
8	Bandra Kurla, Mumbai*	68
9	Siddharth Nagar (IITM), Mumbai	63
10	Navy Nagar (IITM), Mumbai	63
11	Kherwadi Bandra East, Mumbai*	63
12	Byculla, Mumbai*	63
13	Chembur, Mumbai*	62
14	Ghatkopar, Mumbai*	61
15	Mindspace MulundW, Mumbai*	54
16	Sion, Mumbai	52
17	Worli, Mumbai	51
18	MulundW, Mumbai	46
19	Vasai West, Mumbai	46
20	Kandivali East, Mumbai	45

21	Powai, Mumbai	40
22	Vile Parle West, Mumbai	40
23	Colaba, Mumbai	38
24	Khindipada (IITM), Mumbai	35
25	Kurla, Mumbai	32
26	CSIA T2, Mumbai	31
27	Borivali East, Mumbai	29
28	BKC (IITM), Mumbai	
29	Bandra, Mumbai	
30	Chakala (IITM), Mumbai	
31	Bandra (MPCB), Mumbai*	
Hyderabad citywide average		52
1	IDA Pashamylaram, Hyderabad	62
2	ICRISAT, Hyderabad	60
3	Zoo Park, Hyderabad	58
4	Sanathnagar, Hyderabad	57
5	Bollaram, Hyderabad	44
6	Somajiguda, Hyderabad*	43
7	Central University, Hyderabad	39
8	IITH Kandi, Hyderabad*	35
9	Kokapet, Hyderabad*	34
10	New Malakpet, Hyderabad*	34
11	Kompally Municipal Office, Hyderabad*	32
12	ECIL Kapra, Hyderabad*	30
13	Nacharam TSII IALA, Hyderabad*	28
14	Ramachandrapuram, Hyderabad*	25
Bengaluru citywide average		37
1	RVCE, Bengaluru*	56
2	Jigani, Bengaluru*	46
3	Jayanagar, Bengaluru	43
4	Hebbal, Bengaluru	42
5	Bapuji Nagar, Bengaluru	40
6	Peenya, Bengaluru	40
7	Silk Board, Bengaluru	37
8	Hombegowda Nagar, Bengaluru	35
9	Kasturi Nagar, Bengaluru*	32
10	Shivapura Peenya, Bengaluru*	32
11	BTM Layout, Bengaluru	29
12	Sanegurava Halli, Bengaluru	
13	City Railway Station, Bengaluru**	
14	BWSSB, Bengaluru	
Chennai citywide average		36
1	Alandur, Chennai	47
2	Manali, Chennai	47
3	Arumbakkam, Chennai	42
4	Perungudi, Chennai	42
5	Manali Village, Chennai	40
6	Velachery, Chennai	38
7	Royapuram, Chennai	38
8	Kodungaiyur, Chennai	13
9	Gandhi Nagar Ennore, Chennai*	
Delhi citywide average		175
1	Anand Vihar, Delhi	227
2	Wazirpur, Delhi	225
3	Jahangirpuri, Delhi	224
4	Bawana, Delhi	217
5	Vivek Vihar, Delhi	215
6	Nehru Nagar, Delhi	213
7	Rohini, Delhi	211
8	Mundka, Delhi	209
9	Ashok Vihar, Delhi	204
10	Punjabi Bagh, Delhi	198
11	Patparganj, Delhi	194
12	RK Puram, Delhi	194

13	Alipur, Delhi	188
14	Dwarka Sector 8, Delhi	187
15	Sonia Vihar, Delhi	185
16	Burari Crossing, Delhi	182
17	Narela, Delhi	182
18	MDC National Stadium, Delhi	181
19	Okhla Phase 2, Delhi	180
20	Sirifort, Delhi	179
21	DrKS Shooting Range, Delhi	174
22	Mandir Marg, Delhi	172
23	CRRM Mathura Road, Delhi	171
24	Shadipur, Delhi	169
25	North Campus DU, Delhi	166
26	ITO, Delhi	162
27	Pusa (DPCC), Delhi	156
28	IGI Airport T3, Delhi	154
29	Najafgarh, Delhi	152
30	JLN Stadium, Delhi	152
31	Pusa (IMD), Delhi	151
32	Aya Nagar, Delhi	140
33	Lodhi Road, Delhi	128
34	Sri Aurobindo Marg, Delhi	127
35	NSIT Dwarka, Delhi	126
36	IHBAS, Delhi	114
37	DTU, Delhi	93
38	Chandni Chowk (IITM), Delhi*	134
39	Lodhi Road (IITM), Delhi*	132
40	New Moti Bagh, Delhi*	168
41	East Arjun Nagar, Delhi**	
Kolkata citywide average		80
1	Ghusuri, Howrah*	109
2	Padmapukur, Howrah*	109
3	Dasnagar, Howrah*	103
4	Botanical Garden, Howrah*	99
5	Ballygunge, Kolkata	80
6	Fort William, Kolkata	71
7	Bidhannagar, Kolkata	67
8	Belur Math, Howrah*	63
9	Jadavpur, Kolkata	63
10	Victoria, Kolkata	62
11	RB University, Kolkata	60
12	Rabindra Sarobar, Kolkata	54
<p>Note: October-January average of a city is based on mean of daily PM_{2.5} values recorded at CAAQM stations in the city that have adequate data for all winters. * Station does not have adequate data for previous winters and therefore not included in citywide average calculation. ** Station does not have PM_{2.5} monitor.</p> <p>Source: CSE analysis of CPCB's real time air quality data.</p>		