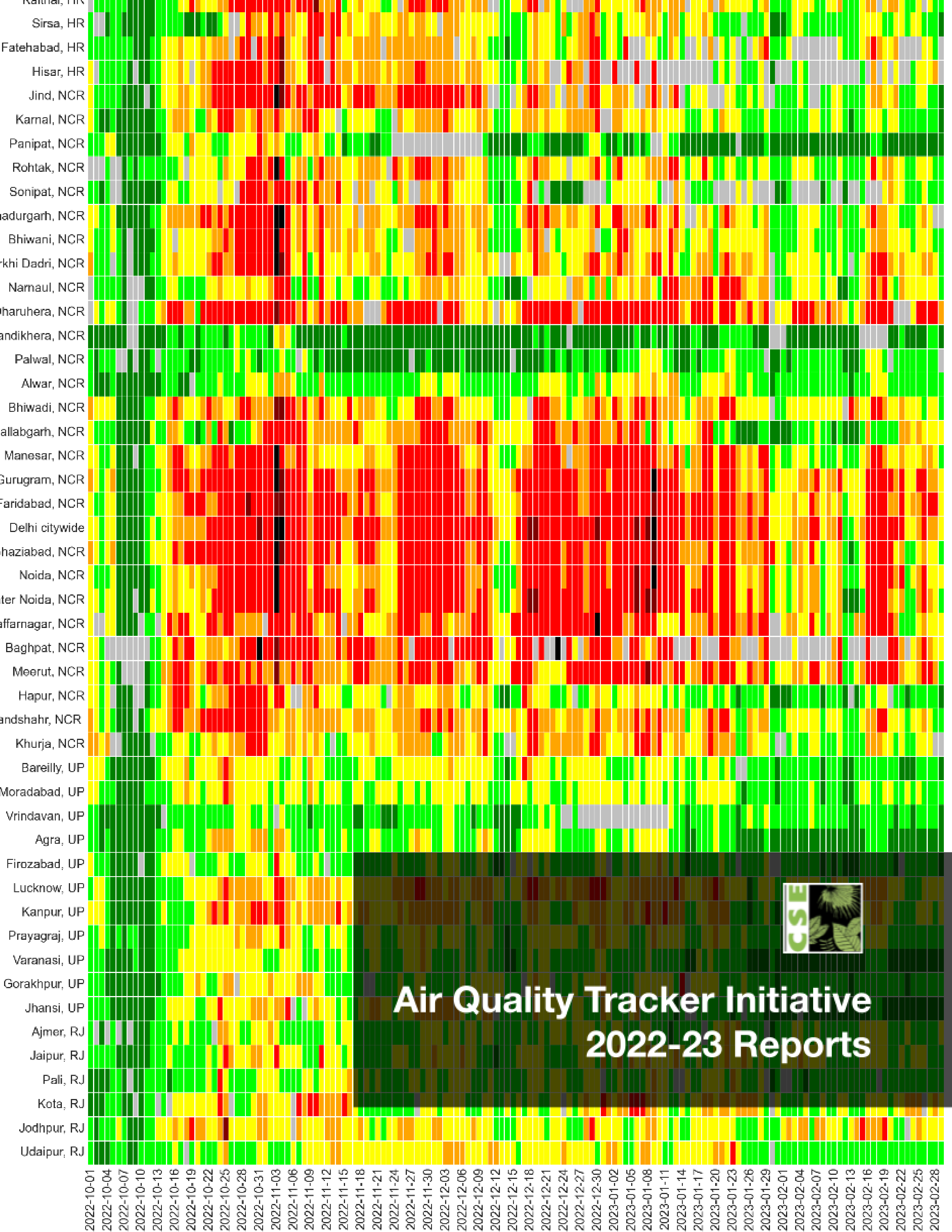
Air Quality Tracker Initiative 2022-23 Reports



Air Quality Tracker Initiative

2022-23 Reports

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CONTENT

Report 1

Winter pollution in India: Overview of the crisis

In 2020 the Urban Lab at the Centre for Science and Environment (CSE) started publishing the state of winter air quality among cities and towns of India that have realtime air quality monitoring. The analysis of the winter of 2022-23 covered 234 cities. The assessment of the seasonal trend in PM2.5 concentration was done by sourcing realtime data from 440 CAAQMS stations via CPCB´s online portal. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis. Winter has been defined as 1 October to 28 February. A minimum of 90 days of valid 24-hour values was deemed mandatory to assign a seasonal/winter PM2.5 level to a station. Cities with multiple stations are represented by the mean of all the city stations that meet the minimum data requirement for both 2021-22 winter and 2022-23 winter.

Regional levels have been constructed using the mean of all cities with valid seasonal levels in the particular region. India level has been determined as the mean of regional levels. These regional and national levels are only indicative.

National and regional: North India was the most polluted region despite registering an improvement of about 15 per cent from the previous winter. Sound India remains the least polluted region but PM2.5 levels have risen almost 17 per cent from the previous year. Pollution rose in West India and Northeast India as well. Central India registered marginal improvement in its winter air quality. Overall, the national average air quality for the 2022-23 winter was 1.32 per cent worse compared to the previous winter (See *Table 1R1: National and regional winter PM2.5 levels*).

Table 1R1: National and regional winter PM2.5 levels

% change WRT to 2021	2022 rank	Region	Seasonal PM2.5 level in µg/m^3
-14.46%	1	North India	82.3
7.94%	2	West India	68.3
-3.20%	3	Central India	65.4
19.06%	4	Northeast India	57.6
16.72%	5	South India	41.3
1.32%		India	63.0

Note: India value is based on the mean of the regional values. Regional level is based on the mean of cities in the region. Average PM2.5 concentration in a city is based on the mean of daily values recorded at CAAQM stations in the city that have minimum 90 valid 24-hour values in the winter. Winter is defined as 1 October-28 February. Green cell symbolises improvement from the previous winter while red cell symbolises deterioration.
Source: CSE analysis of CPCB's real time air quality data

<u>Cities and towns</u>: Towns of Bihar completely dominate the most polluted list with Begusarai on the top. Delhi was the most polluted major city and this year ranked at 11th place among 185 cities that had valid seasonal PM2.5 level (minimum 90 valid 24-hour values during the winter). Least polluted cities and towns are located in south India and hills of Northeast (See *Table 1R2: Winter PM2.5 levels among cities and towns of India)*

Table 1R2: Winter PM2.5 levels among cities and towns of India

Change WRT to 2021	2022 rank	City	State	Seasonal PM2.5 level in µg/m^3
New	1	Begusarai	Bihar	283.3
	2	Siwan	Bihar	208.8
	3	Bettiah	Bihar	204.0
	4	Darbhanga	Bihar	196.9
	5	Katihar	Bihar	192.6
	6	Saharsa	Bihar	182.0
	7	Purnia	Bihar	181.8
New	8	Samastipur	Bihar	169.7
	9	Chhapra	Bihar	163.4
	10	Bhagalpur	Bihar	156.6
	11	Delhi*	Delhi	151.5
	12	Patna*	Bihar	147.6
	13	Muzaffarpur*	Bihar	143.1
	14	Munger	Bihar	138.7
	15	Bihar Sharif	Bihar	137.9
	16	Araria	Bihar	135.4
	17	Dharuhera	Haryana	134.2
	18	Baghpat*	UP	132.1
	19	Greater Noida*	UP	132.0
	20	Rajgir	Bihar	131.7
	21	Faridabad*	Haryana	129.9
	22	Buxar	Bihar	129.5
	23	Gurugram*	Haryana	129.4
	24	Vapi	Gujarat	128.2
	25	Ghaziabad*	UP	125.1
New	26	Nalbari	Assam	122.0
	27	Meerut*	UP	119.9
	28	Arrah	Bihar	118.8
	29	Noida*	UP	118.3
	30	Gwalior*	MP	115.9
	31	Singrauli	MP	113.2
	32	Kishanganj	Bihar	111.7
	33	NaviMumbai*	Maharashtra	110.5
	34	Gaya*	Bihar	110.4
	35	Manesar	Haryana	107.0
	36	Motihari	Bihar	106.6
	37	Sasaram	Bihar	106.6
	38	Hajipur	Bihar	105.2
	39	Surat	Gujarat	103.3

Change WRT to 2021	2022 rank	City	State	Seasonal PM2.5 level in µg/m³
	40	Jind	Haryana	102.3
	41	Asansol	West Bengal	102.1
	42	Baddi	Himachal Pradesh	99.6
	43	Bahadurgarh	Haryana	98.4
	44	Guwahati*	Assam	96.8
	45	Charkhi	Haryana	96.0
	46	Bulandshahr	UP	96.0
	47	Hisar	Haryana	94.5
	48	Bhiwadi	Rajasthan	93.2
	49	Howrah*	West Bengal	92.8
	50	Agartala*	Tripura	90.5
	51	Kaithal	Haryana	90.5
	52	Chandigarh*	Chandigarh	90.4
	53	Ludhiana	Punjab	89.8
	54	Katni	MP	89.5
New	55	Bileipada	Odisha	88.3
	56	Kurukshetra	Haryana	88.0
	57	Mandi Gobindgarh	Punjab	86.2
	58	Fatehabad	Haryana	86.0
	59	Jabalpur	MP	85.7
	60	Ballabgarh	Haryana	85.5
New	61	Keonjhar	Odisha	84.4
	62	Rohtak	Haryana	84.3
New	63	Rairangpur	Odisha	84.2
	64	Bhiwani	Haryana	84.2
New	65	Baripada	Odisha	84.1
	66	Ankleshwar	Gujarat	83.3
	67	Lucknow*	UP	82.8
New	68	Khurja	UP	82.1
	69	Yamuna Nagar	Haryana	81.0
No change	70	Kolkata*	West Bengal	80.2
	71	Nagpur	Maharashtra	79.2
	72	Kanpur*	UP	77.3
	73	Gummidipoondi	Tamil Nadu	77.2
	74	Amritsar	Punjab	76.9
	75	Mumbai*	Maharashtra	76.9
	76	Jodhpur	Rajasthan	76.0
New	77	Nayagarh	Odisha	75.9
	78	Narnaul	Haryana	75.8
	79	Talcher	Odisha	75.6
	80	Ujjain	MP	74.5
	81	Karnal	Haryana	74.0
	82	Ambala	Haryana	74.0
	83	Kota	Rajasthan	73.4
	84	Manguraha	Bihar	73.2

Change WRT to 2021	2022 rank	City	State	Seasonal PM2.5 level in µg/m^3
	85	Bhopal*	MP	73.1
	86	Chandrapur*	Maharashtra	70.9
	87	Visakhapatnam	Andhra Pradesh	70.6
	88	Sonipat	Haryana	69.9
	89	Durgapur	West Bengal	69.5
No change	90	Sirsa	Haryana	69.4
	91	Hapur	UP	68.9
	92	Jalandhar	Punjab	68.8
	93	Pune*	Maharashtra	67.5
	94	Vatva	Gujarat	65.8
	95	Udaipur	Rajasthan	65.6
	96	Kalyan	Maharashtra	65.4
	97	Jaipur*	Rajasthan	64.9
	98	Panchkula	Haryana	63.3
New	99	Tensa	Odisha	62.7
	100	Patiala	Punjab	62.3
	101	Ahmedabad*	Gujarat	62.0
	102	Rupnagar	Punjab	61.3
	103	Pithampur	MP	60.4
	104	Moradabad*	UP	60.1
	105	Siliguri	West Bengal	59.9
	106	Khanna	Punjab	59.8
	107	Hyderabad*	Telangana	59.5
	108	Prayagraj*	UP	58.4
New	109	Bareilly*	UP	58.1
	110	Aurangabad	Maharashtra	57.5
	111	Gorakhpur	UP	56.8
	112	Rajamahendravaram	Andhra Pradesh	56.7
	113	Ajmer	Rajasthan	56.4
No change	114	Nashik	Maharashtra	56.0
No change	115	Bhatinda	Punjab	55.9
	116	Mandideep	MP	54.7
	117	Pali	Rajasthan	54.6
	118	Kochi*	Kerala	54.4
New	119	Belgaum	karnataka	54.3
	120	Jhansi	UP	54.2
	121	Kalaburagi	Karnataka	53.9
	122	Gandhinagar*	Gujarat	52.7
	123	Alwar	Rajasthan	52.4
	124	Ratlam	MP	52.4
	125	Firozabad*	UP	49.9
	126	Amaravati	Andhra Pradesh	49.7
	127	Dewas	MP	49.3
New	128	Hosur	karnataka	49.2
	129	Coimbatore	Tamil Nadu	47.8
	130	Bengaluru*	Karnataka	46.7

Change WRT to 2021	2022 rank	City	State	Seasonal PM2.5 level in $\mu g/m^3$
	131	Hubballi	Karnataka	46.4
	132	Agra*	UP	45.9
	133	Chikkaballapur	Karnataka	45.9
	134	Thrissur	Kerala	45.7
	135	Haldia	West Bengal	45.5
	136	Tirupati	Andhra Pradesh	45.2
	137	Varanasi*	UP	44.8
New	138	Haveri	karnataka	44.8
New	139	Tirupur	Tamil Nadu	44.5
	140	Brajrajnagar	Odisha	44.4
	141	Bhilai*	Chhattisgarh	44.1
	142	Mangalore	Karnataka	43.8
	143	Nandesari	Gujarat	43.4
	144	Solapur	Maharashtra	43.2
	145	Kannur	Kerala	43.1
	146	Chennai*	Tamil Nadu	42.4
	147	Srinagar	J&K	42.0
	148	Yadgir	Karnataka	41.5
	149	Vrindavan	UP	40.7
New	150	Imphal*	Manipur	39.4
	151	Ramanagara	Karnataka	39.1
	152	Shillong*	Meghalaya	38.4
	153	Sagar*	MP	38.4
	154	Puducherry	Puducherry	37.5
	155	Panipat	Haryana	37.0
	156	Indore	MP	36.8
	157	Thiruvananthapuram*	Kerala	36.6
	158	Damoh	MP	36.4
	159	Davanagere	Karnataka	36.3
	160	Kohima	Nagaland	36.1
	161	Palwal	Haryana	36.0
	162	Hassan	Karnataka	33.1
	163	Kollam	Kerala	32.9
	164	Kozhikode	Kerala	32.7
New	165	Gangtok	Sikkim	31.1
New	166	Anantapur	Andhra Pradesh	30.9
	167	Koppal	Karnataka	30.2
New	168	Ooty	Tamil Nadu	29.7
	169	Naharlagun	Arunachal Pradesh	28.2
	170	Raichur	Odisha	27.2
New	171	Ramanathapuram	Tamil Nadu	26.7
	172	Bilaspur	Chhattisgarh	26.5
	173	Gadag	Karnataka	26.2
	174	Mandikhera	Haryana	23.5
	175	Maihar	MP	21.8

Change WRT to 2021	2022 rank	City	State	Seasonal PM2.5 level in µg/m3
	176	Mysuru	Karnataka	21.8
New	177	Sivasagar	Assam	21.1
	178	Satna	MP	21.0
	179	Bagalkot	Karnataka	20.9
	180	Shivamogga	Karnataka	20.6
	181	Vijayapura	Karnataka	20.3
	182	Chikkamagaluru	Karnataka	20.0
	183	Madikeri	Karnataka	19.3
	184	Chamarajanagar	Karnataka	18.1
	185	Aizawl	Mizoram	12.4

Note: Average PM2.5 concentration in a city is based on the mean of daily values recorded at CAAQM stations in the city that have minimum 90 valid 24-hour values in the winter. Winter is defined as 1 October-28 February. Green cell symbolises improvement from the previous winter while red cell symbolises deterioration. * City with multiple stations and the city value is based on the mean of all the city stations with valid seasonal levels.
Source: CSE analysis of CPCB's real time air quality data

Report 2

Winter pollution in megacities: The growing crisis outside Delhi

As the winter season comes to a close, an analysis of PM2.5 trends in five megacities in comparison to Delhi has been conducted by the Urban Lab at the Centre for Science and Environment (CSE). All mega cities, despite being located in different geo climatic zones, have faced the challenge of worsening PM2.5 levels during this winter season. While the levels in Delhi that is located in the land locked northern plains, has been the highest among all mega cities, the rest have also experienced very poor to worsening trends.

This has emerged from the analysis of real time PM2.5 data in Delhi, Kolkata, Mumbai, Hyderabad, Bengaluru and Chennai for the winter period (October 1- February 28), by the Urban Lab at the Centre for Science and Environment (CSE). The objective of this analysis has been to assess the peer megacities for longer term seasonal variation and annual trends in particulate pollution. All five megacities registered a higher seasonal PM2.5 average this winter compared to the previous winter. Which is opposite of Delhi which registered its least polluted winter compared to previous 4 four winters. This is the challenge of sprawling urbanisation and rapid motorization.

While Delhi's winter air quality hogs all attention, the rising winter air pollution in other mega cities including Kolkata, Mumbai, Hyderabad, Bengaluru and Chennai, do not get adequate attention. While Delhi has bent its seasonal pollution curve, winter air quality is high or on the rise in most other megacities. These cities outside the northern plains may have more favourable meteorological conditions to contain the peaking of pollution during the winter, but their overall city average and levels across locations inside cities can cause very high exposures. This demands round the year action to control emissions in cities that are motorizing and urbanising rapidly.

Winter season presents a serious challenge in all megacities despite them being located in different geo climatic zones with varying meteorological and topographical conditions. The PM2.5 levels remain elevated and also the levels peak during winter in all megacities. This winter several mega cities (excluding Delhi) have recorded higher seasonal PM2.5 average compared to their previous winter. This clearly indicates that the overall emissions are high or may be rising in those cities.

Data used in the analysis: This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019-20, 2020-21, 2021-22 and 2022-23. This analysis is based on the real time data available from the current working air quality monitoring stations in Delhi, Kolkata-Howrah, Mumbai, Chennai, Hyderabad and Bengaluru. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis. This analysis covers 106 continuous ambient air quality monitoring stations (CAAQMS) spread across metro cities. Delhi (40), Kolkata (7), Mumbai (21), Hyderabad (14), Bengaluru (12), 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.

Key highlights

<u>Among the mega cities, Kolkata and Mumbai are the most polluted after Delhi, while air quality has worsened fastest in Bengaluru and Chennai</u>: Delhi with winter average PM2.5 of 151 µg/m^3 remains the most polluted megacity by a large margin but it has shown improvement over the past few years. But in other five megacities, the average PM2.5 level this winter (October to February) stood at 80 µg/m^3 for Kolkata and at 77 µg/m^3 for Mumbai both higher than 24-hour standard for PM2.5 (*See Graph 2R1: Winter pollution in megacities*). Hyderabad's winter average of 59 µg/m^3 is just under the 24-hour standard. Bengaluru with 44 µg/m^3 and Chennai µg/m^3 with 42 were comfortably under the 24-hour standard but breached the annual standard for PM2.5.

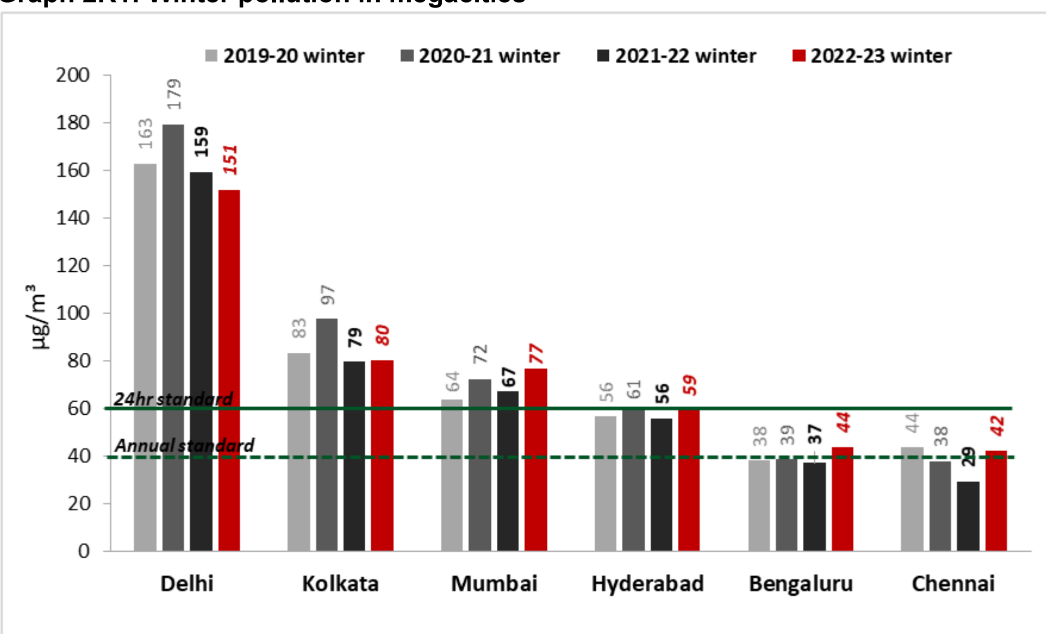
– Compared to winter of 2021-22 only Delhi has shown improvement in winter air quality and its winter air is 9 per cent less polluted than previous winter. But the winter average of PM2.5 has increased in the rest of the five megacities.

– When the PM2.5 level of the current winter is compared with the average for the previous three winters, Bengaluru and Chennai's performance is the worst as their winter air is 15 per cent more polluted than average of their previous three winters.

– Mumbai's winter air is 14 per cent and Hyderabad's winter air is 3 per cent more polluted.

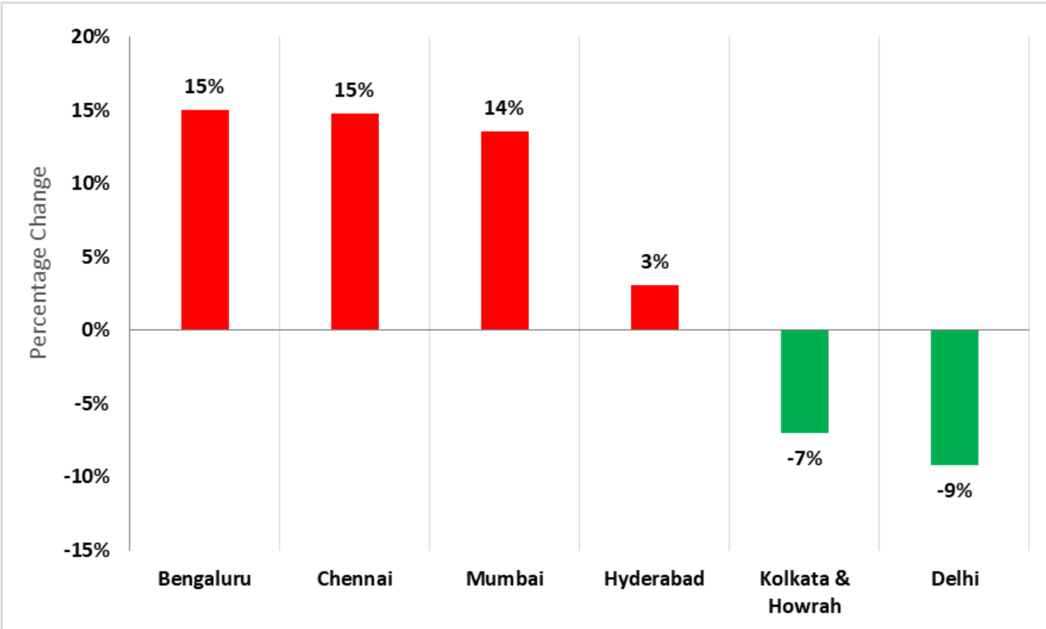
– Kolkata's overall winter average of PM2.5 has improved compared to previous three years but has stagnated since last year. Kolkata's winter air is 7 per cent less polluted compared to the average of previous three winters, but this winter's pollution level is identical to last winter level showing a stagnant trend (See *Graph 2R2: Change in winter PM2.5 level among megacities compared to mean of previous three winters*).

Graph 2R1: Winter pollution in megacities



Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for all four winters. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data

Graph 2R2: Change in winter PM2.5 level among megacities compared to the mean of previous three winters



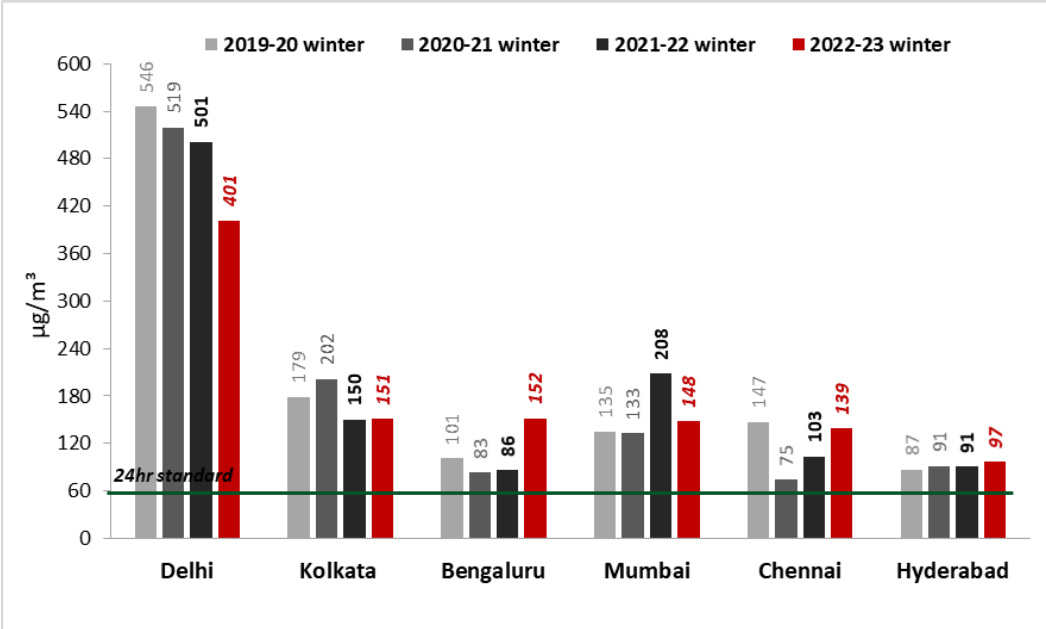
Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data

Peak winter pollution in Bengaluru and Hyderabad is the worst in the last four years: On 27 January 2023, daily PM2.5 level in Bengaluru hit 152 µg/m^3 which was the highest 24-hour PM2.5 average recorded in the city since 2019. Similarly, Hyderabad registered its highest 24-hour PM2.5 average since 2019 this winter on 23 February 2023 when daily average reached 97 µg/m^3. Peak daily value this winter for Kolkata, Mumbai and Chennai was not as high as their previous winter peaks but still in the "very poor" AQI category (See *Graph 2R3: Winter peak pollution levels in megacities*). Kolkata's winter peak stood at 151 µg/m^3 registered on 21 January 2023, for Mumbai it stood at 148 µg/m^3 registered on 18 January 2023, and for Chennai it stood at 139 µg/m^3 registered on 24 October 2022. Delhi's peak pollution this winter stood at 401 µg/m^3 and it was registered on 3 November 2022.

When PM2.5 peak level of the current winter is compared to the average for previous three winters, Bengaluru's performance works out to be the worst as its winter peak was 68 per cent higher than average of its previous three winter peaks. Similarly, Chennai's winter peak was 28 per cent higher, and Hyderabad's winter peak was 8 per cent higher (See *Graph 2R4: Change in winter PM2.5 peak level among megacities compared to mean of previous three winters*).

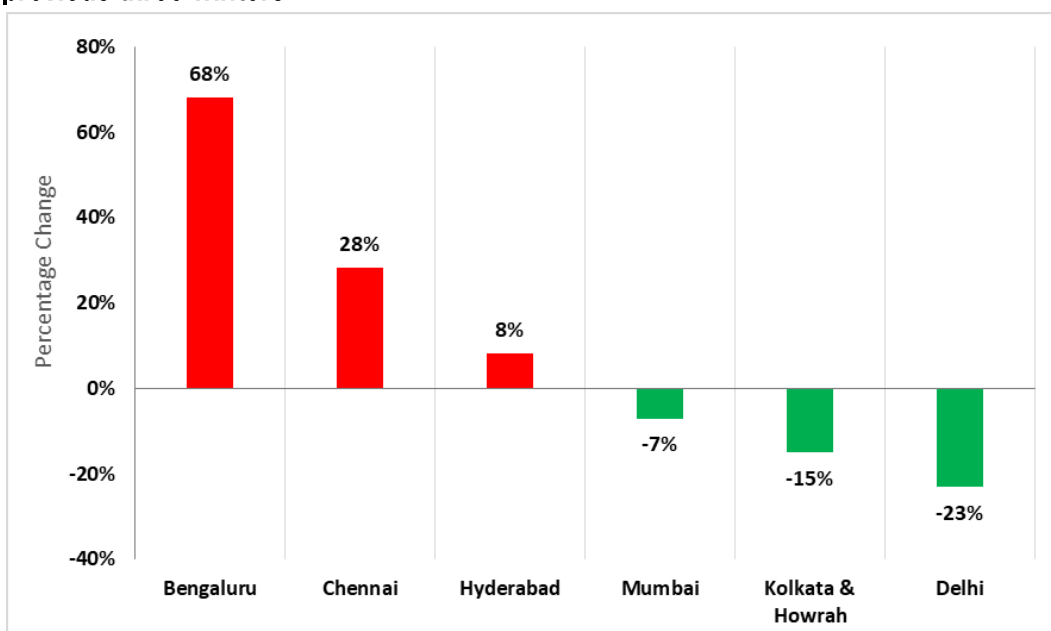
Delhi, Kolkata and Mumbai had lower peaks compared to the average of the previous three winter peaks. Mumbai's winter peak was 7 per cent lower, Kolkata's winter peak was 15 per cent lower and Delhi's winter peak was 23 per cent lower than the average of previous three winter peaks.

Graph 2R3: Winter peak pollution levels in megacities



Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data

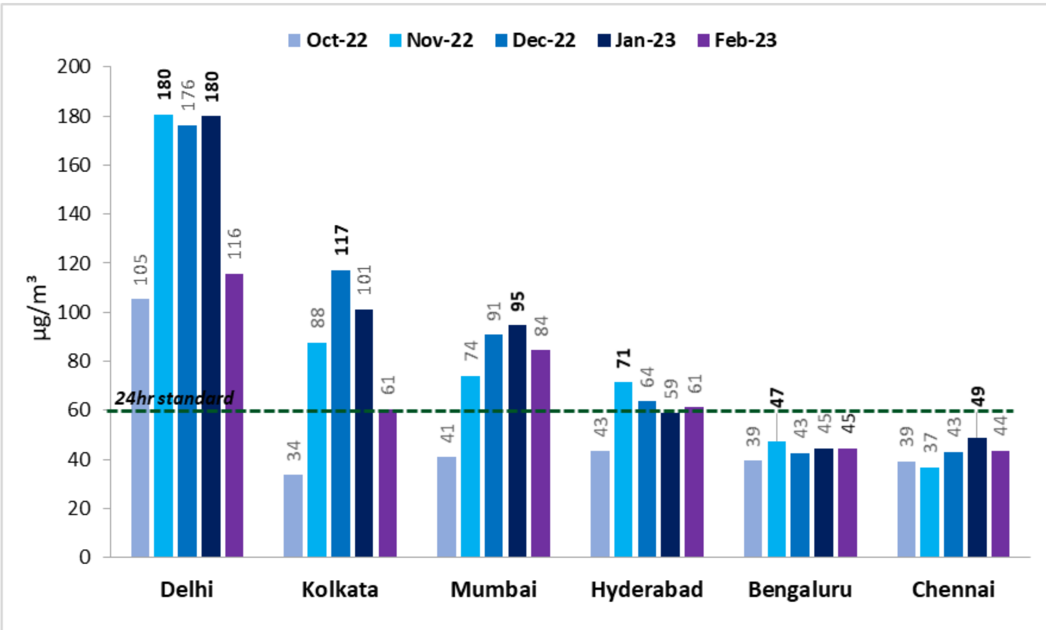
Graph 2R4: Change in winter PM2.5 peak level among megacities compared to the mean of previous three winters



Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data

<u>Monthly air quality patterns vary across the megacities</u>: Unlike Delhi which has two pollution crests during the winter season (November and January), other megacities have just one crest. November is the worst air quality month for Hyderabad and Bengaluru. Worst month for Mumbai and Chennai has been January (See *Graph 2R5: Monthly pollution levels in megacities*). Kolkata's worst month is December. Kolkata was the most polluted megacity (excluding Delhi) for months of November, December and January. In February, Mumbai overtook Kolkata as the most polluted megacity (excluding Delhi).

Graph 2R5: Monthly pollution levels in megacities



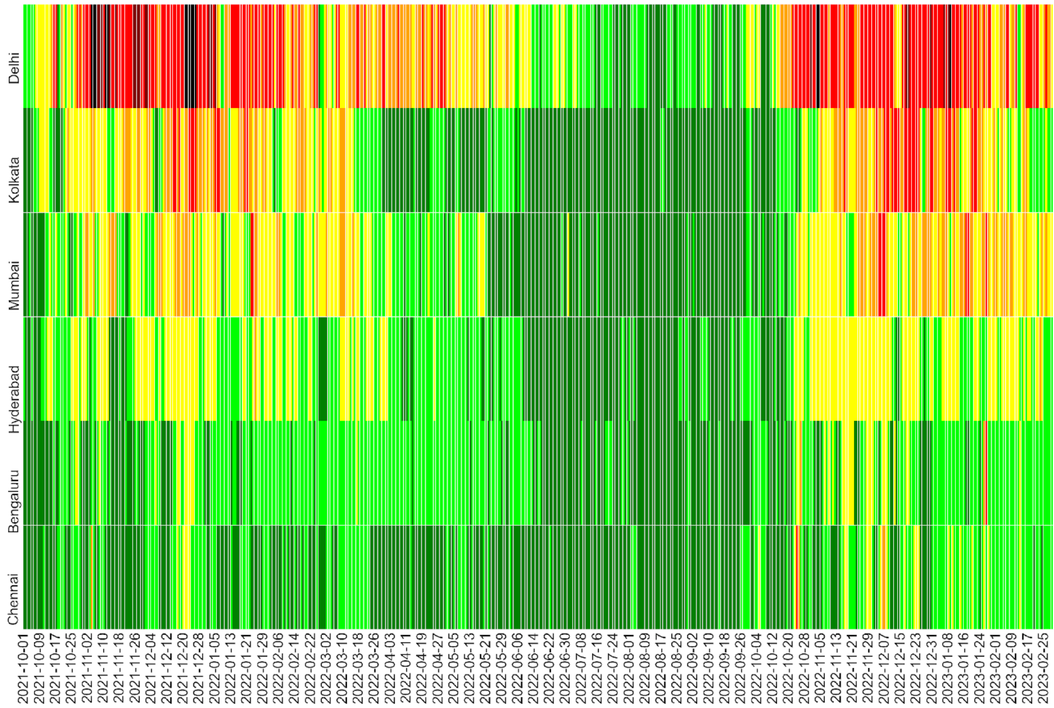
Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data

<u>Winter is a problematic season for all megacities but intensity of the problem varies</u>: 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, Mumbai and Hyderabad, but of shorter duration in Bengaluru and Chennai (See *Graph 2R6: 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 *2R7*: Daily pollution levels in megacities). Other than Delhi, compared to previous winter, the number of bad air days were more in other megacities.

<u>Kolkata's longer term seasonal PM2.5 trend was lower but had the highest number of "very poor" AQI days; Mumbai had least number of "good"AQI days among the megacities (excluding Delhi)</u>: Kolkata registered 26 days of "very poor" AQI this winter which is second only to Delhi. It was followed by Mumbai that had seven days of "very poor" AQI. Chennai and Bengaluru registered just one day of "very poor" AQI while Hyderabad registered zero days with "very poor" AQI (see *Graph 2R8: Distribution of AQI days for megacities*).

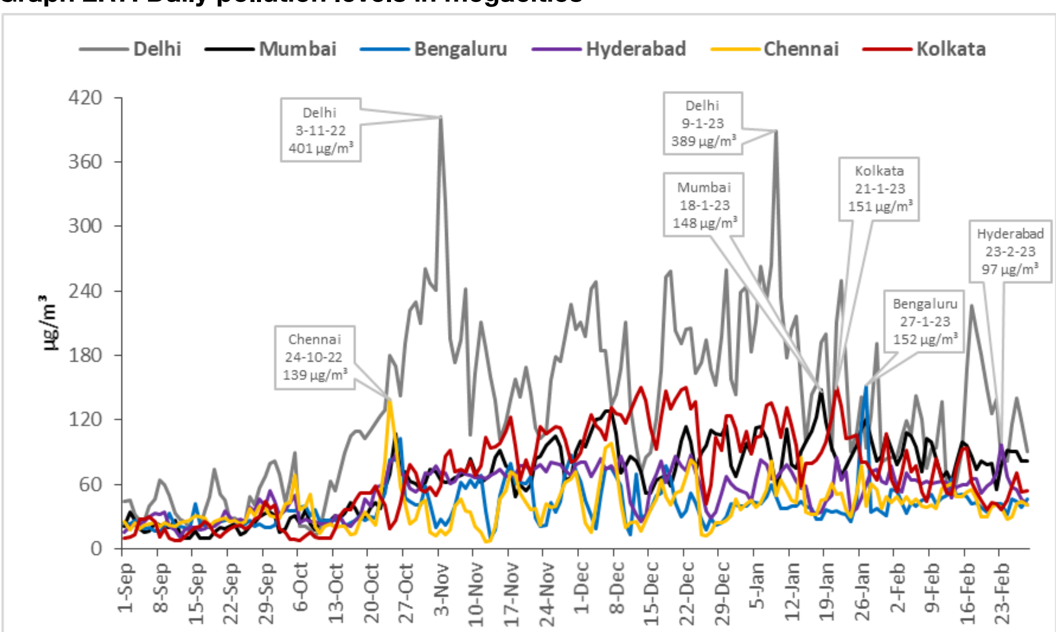
Mumbai had only 12 days of "good" AQI which is lower than Kolkata (14 "good" AQI days) despite having a relatively lower number of bad air days. Chennai (43 "good" AQI days) and Bengaluru (33 "good" AQI days) had the most "good" AQI days among the megacities. Hyderabad had only 15 "good" AQI days. Delhi was the worst megacity with 9 "severe" AQI days, 87 "very poor" days and 5 "good" AQI days.

Graph 2R6: PM2.5 calendar for megacities



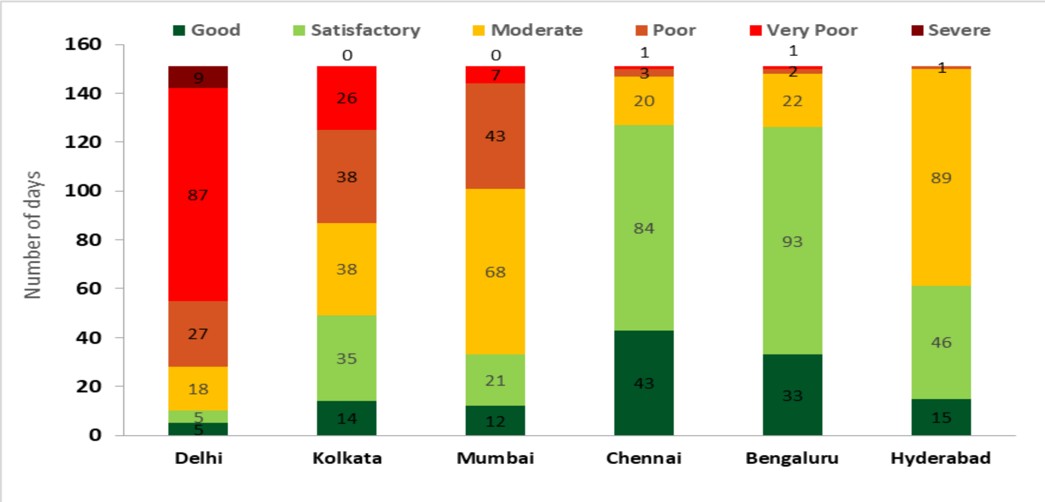
Note: Average PM2.5 concentration is based on the mean of daily values recorded at all CAAQM stations in the city that have adequate data for the winter. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB's real time air quality data

Graph 2R7: Daily pollution levels in megacities



Note: Average PM2.5 concentration is based on the mean of daily values recorded at all CAAQM stations in the city that have adequate data for the winter. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data

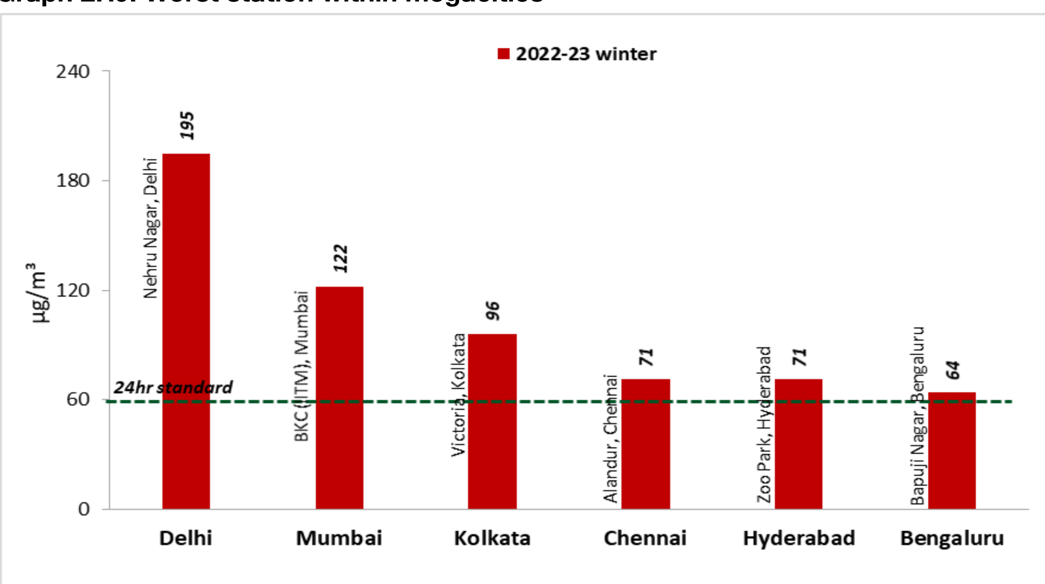
Graph 2R8: Distribution of AQI days for megacities



Note: Average PM2.5 concentration is based on the 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

<u>Worst affected locations within megacities have pollution levels 50 per cent higher than citywide average</u>: There is considerable variation in air quality among the locations of each megacity with worst locations being considerably more polluted than citywide average. In Mumbai the worst air quality was recorded at Bandra-Kurla Complex (BKC) whose seasonal average stood at 122 µg/m^3. In fact five of the six most polluted locations among the 66 monitoring stations among the five megacities are in Mumbai. For Kolkata the most polluted location was Victoria with the winter average of 96 µg/m^3. Neighbouring twin city of Howarh has been worse off with Ghusuri in Howrah recording the winter average of 128 µg/m^3. Alandur was the most polluted location in Channai with a seasonal average of 71 µg/m^3. Zoo Park was the most polluted location in Hyderabad with a seasonal average of 71 µg/m^3. In Bengaluru, the most polluted location was Bapuji Nagar and its seasonal average was 64 µg/m^3 (See *Graph 2R9: Worst station within megacities & Annexure 2R: Winter PM2.5 level at station levels among megacities)*.

Graph 2R9: Worst station within megacities



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

Way forward

The winter period is a special challenge in all cities as adverse meteorological conditions trap pollution and increase concentration and exposures. The impact is worse if the overall pollution in the city is high and is worsening. This demands stringent action round the year as well as emergency action during the bad-air days to bring down the overall pollution levels. This demands stringent action to reduce emissions from vehicles, industry, waste burning, construction, solid fuels in households among others. This is also needed to meet the new target of 40 per cent reduction in particulate pollution under the National Clean Air Programme.

Annexure 2R

Winter PM2.5 level at station levels among megacities

	Station name	2022-23 winter PM2.5 level in µg/m^3
Mumbai citywide average		**77**
1	BKC (IITM), Mumbai	122
2	Deonar (IITM), Mumbai	121
3	Mazgaon (IITM), Mumbai	109
4	Navy Nagar (IITM), Mumbai	107
5	Chakala (IITM), Mumbai	97
6	Vile Parle West, Mumbai	89
7	Borivali East (IITM), Mumbai	83
8	Sion, Mumbai	82
9	Mulund West, Mumbai	82
10	Khindipada (IITM), Mumbai	77
11	Powai, Mumbai	71
12	Kandivali East, , Mumbai	68
13	Borivali East, Mumbai	60
14	Colaba, Mumbai	60
15	Worli, Mumbai	59
16	Siddharth Nagar (IITM), Mumbai	57
17	CSI Airport T2, Mumbai	57
18	Vasai West, Mumbai	54
19	Malad West (IITM), Mumbai	48
20	Kurla, Mumbai	38
21	Bandra, Mumbai	
Hyderabad citywide average		**59**
1	Zoo Park, Hyderabad	71
2	Sanathnagar, Hyderabad	67
3	IDA Pashamylaram, Hyderabad	62
4	Bollaram, Hyderabad	60
5	ICRISAT, Hyderabad	59
6	Somajiguda, Hyderabad*	48
7	Central University, Hyderabad	44
8	Nacharam TSIICIALA, Hyderabad*	39
9	Ramachandrapuram, Hyderabad*	38
10	Kokapet, Hyderabad*	37
11	New Malakpet, Hyderabad*	37
12	IITH Kandi, Hyderabad*	36
13	Kompally Municipal Office, Hyderabad*	33
14	ECIL Kapra, Hyderabad*	30
Bengaluru citywide average		**47**
1	Bapuji Nagar, Bengaluru	64
2	RVCE, Bengaluru*	54

	Station name	2022-23 winter PM2.5 level in µg/m³
3	Silk Board, Bengaluru	45
4	Hebbal, Bengaluru	44
5	Jayanagar, Bengaluru	44
6	BTM Layout, Bengaluru	41
7	Shivapura, Bengaluru*	40
8	Peenya, Bengaluru	40
9	Hombegowda Nagar, Bengaluru	31
10	BWSSB, Bengaluru	
11	City Railway Station, Bengaluru**	
12	Sanegurava Halli, Bengaluru	
Chennai citywide average		**42**
1	Alandur, Chennai	71
2	Manali Village, Chennai	63
3	Gandhi Nagar Ennore, Chennai*	46
4	Royapuram, Chennai	44
5	Perungudi, Chennai	44
6	Arumbakkam, Chennai	42
7	Manali, Chennai	41
8	Velachery, Chennai	32
9	Kodungaiyur, Chennai	21
Delhi citywide average		**151**
1	Nehru Nagar, Delhi	195
2	Jahangirpuri, Delhi	187
3	Anand Vihar, Delhi	184
4	Vivek Vihar, Delhi	177
5	Wazirpur, Delhi	175
6	Mundka, Delhi	174
7	Patparganj, Delhi	173
8	NSIT Dwarka, Delhi	172
9	Shadipur, Delhi	171
10	Rohini, Delhi	170
11	Bawana, Delhi	169
12	Burari Crossing, Delhi	168
13	Narela, Delhi	168
14	ITO, Delhi	167
15	RK Puram, Delhi	166
16	Sonia Vihar, Delhi	165
17	Dwarka Sector 8, Delhi	164
18	Punjabi Bagh, Delhi	163
19	Alipur, Delhi	161
20	Ashok Vihar, Delhi	160
21	National Stadium, Delhi	159
22	Pusa (DPCC), Delhi	156
23	Okhla Phase 2, Delhi	155
24	JLN Stadium, Delhi	153

	Station name	2022-23 winter PM2.5 level in $\mu g/m^3$
25	Dr KS Shooting Range, Delhi	150
26	Sirifort, Delhi	147
27	North Campus DU, Delhi	144
28	Sri Aurobindo Marg, Delhi	139
29	CRRI Mathura Road, Delhi	137
30	Mandir Marg, Delhi	131
31	IGI Airport T3, Delhi	124
32	Pusa (IMD), Delhi	121
33	Najafgarh, Delhi	121
34	IHBAS, Delhi	112
35	Aya Nagar, Delhi	111
36	DTU, Delhi	108
37	Lodhi Road, Delhi	108
38	Lodhi Road (IITM), Delhi*	179
39	Chandni Chowk (IITM), Delhi*	102
40	East Arjun Nagar, Delhi**	
Kolkata citywide average		**80**
1	Ghusuri, Howrah*	128
2	Victoria, Kolkata	96
3	R.B. University, Kolkata	91
4	Jadavpur, Kolkata	90
5	Bidhannagar, Kolkata	85
6	Ballygunge, Kolkata	85
7	Padmapukur, Howrah*	78
8	Belur Math, Howrah*	78
9	Rabindra Sarobar, Kolkata	64
10	Fort William, Kolkata	57

Note: October-February average of a city is based on the mean of daily PM2.5 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 is not included in citywide average calculation. ** Station does not have a PM2.5 monitor. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data.

Report 3

North Indian winter pollution: Overview of air quality during winter beyond Delhi

Half way through the winter the Urban Lab at Centre for Science and Environment (CSE) has analysed air quality trends so far in North India. The focus is on Punjab, Haryana, Uttar Pradesh, Rajasthan, Jammu & Kashmir, Uttarakhand and Himachal Pradesh in addition to Delhi-NCR. The objective has been to understand behaviour of the winter pollution in this region this October, November and December till 18^{th}. This also helps to locate the winter season within the longer term context of seasonal variation and annual trends in particulate pollution. This is part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on Delhi's air quality.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019-20, 2020-21, 2021-22 and 2022-23. North India has been divided into five sub-regions for analysis sake in this study. Sub-regions have been defined as Punjab & Chandigarh, NCR (includes Delhi and 26 other cities/towns that fall inside NCR), Haryana (excluding cities in NCR), Uttar Pradesh (excluding cities in NCR), and Rajasthan (excluding cities in NCR). The Himalayan states (Jammu & Kashmir, Himachal Pradesh, and Uttrakhand) are not included in the sub–regions, since the monitoring stations there started operating only in the middle of 2022. Therefore, only the five sub-regions have been considered for the long term-analysis.

This analysis is based on the real time data available from the current working air quality monitoring stations in North India. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis. This analysis covers 151 continuous ambient air quality monitoring stations (CAAQMS) spread across 65 cities.

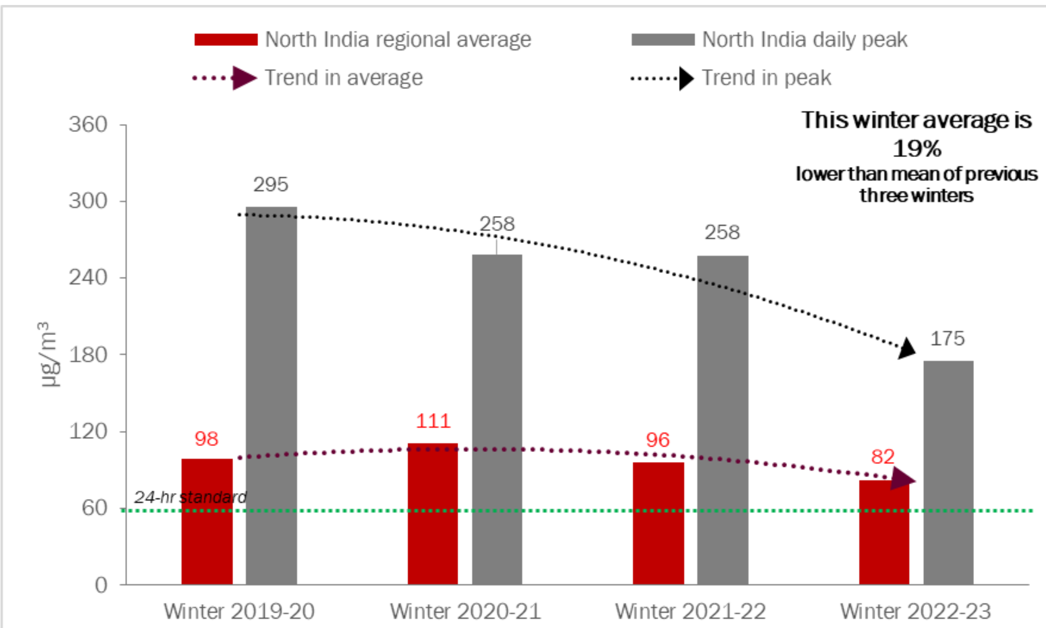
This winter started on the cleanest note due to an extended rainfall period that went deep into the month of October. These good meteorological conditions were complimented by reduced quantity and intensity of farm stubble fires. The regional pollution level so far in North India has been the lowest compared to the previous four years. Worsening of air quality is spatially and temporally synchronised across North India with Delhi being the epicentre with worst air quality in the region. Delhi-NCR, Haryana and Uttar Pradesh cities show most improvement compared to previous year while cities of Punjab and Rajasthan show worsening from previous seasons. The analysis also noted that smaller towns are as polluted as bigger cities.

Key findings: Regional

This winter was the least polluted in the last four years: The average PM2.5 level across 55 cities of North India with functional CAAQMS stations stood at 82 µg/m^3 for the time period of 1 October 2022 to 28 February 2023. This is the lowest level recorded in the last four years (See *Graph 3R1: Trend in North India's PM2.5 levels during winters*). PM2.5 level this winter has been 19 per cent lower compared to the mean of the previous three winters.

Daily peak this season happened on 3 November 2022 and the daily regional average stood at 175 µg/m^3. Peak was also the lowest in the last four years. The PM2.5 peak this winter has been 35 per cent lower compared to the mean of previous three winter peaks.

Graph 3R1: Trend in North India's PM2.5 levels during winters

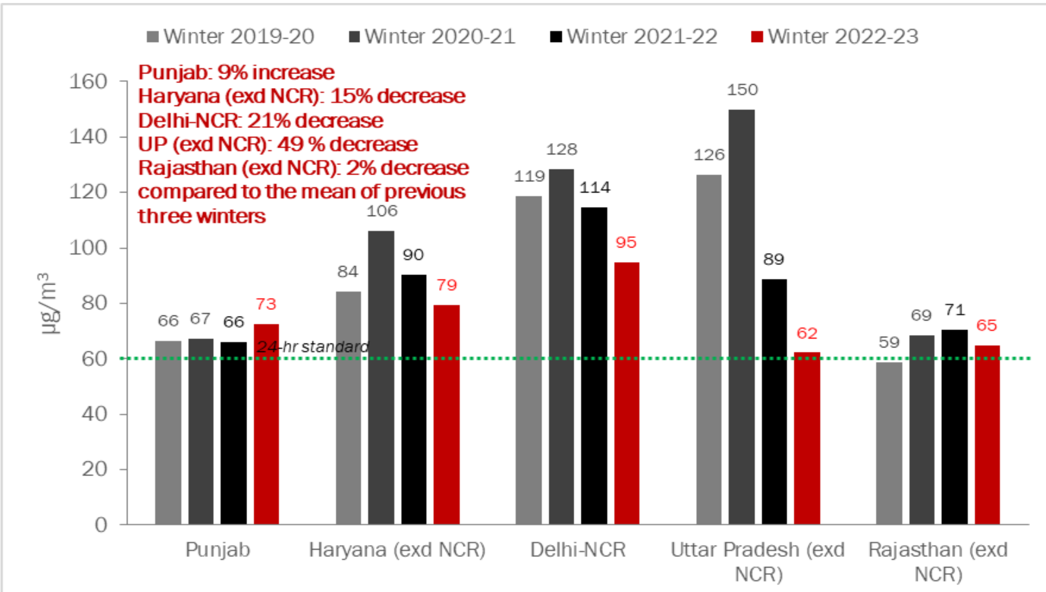


Note: 55 cities that constitute North India regional average are Agra, Ajmer, Alwar, Ambala, Amritsar, Baghpat, Bahadurgarh, Ballabgarh, Bhatinda, Bhiwadi, Bhiwani, Bulandshahr, Chandigarh, Charkhi Dadri, Delhi, Dharuhera, Faridabad, Fatehabad, Ghaziabad, Greater Noida, Gurugram, Hapur, Hisar, Jaipur, Jalandhar, Jind, Jodhpur, Kaithal, Kanpur, Karnal, Khanna, Kota, Kurukshetra, Lucknow, Ludhiana, Mandi Gobindgarh, Mandikhera, Manesar, Meerut, Moradabad, Muzaffarnagar, Narnaul, Noida, Pali, Palwal, Panchkula, Panipat, Patiala, Rohtak, Rupnagar, Sirsa, Sonipat, Udaipur, Varanasi, and Yamuna Nagar. Winter is defined as 1 October-28 February. Winter average is based on the mean of daily averages.
Source: CSE analysis of CPCB realtime data

All major sub-regions of North India except Punjab registered lesser winter pollution; seasonal PM2.5 level rose by 9 per cent in Punjab: Winter pollution level in Punjab rose by 9 per cent compared to the mean of previous three winters. Punjab was the only sub-region to register an increase in North India. Delhi-NCR's winter PM2.5 average this year is 21 per cent lower than the mean of previous three winters. Uttar Pradesh (excluding NCR cities) registered 49 per cent improvement in winter air quality exceeding Delhi-NCR performance. Haryana (excluding NCR cities) shows 15 per cent improvement (See *Graph 3R2: Trend in winter PM2.5 levels among the sub-regions of North India*). Rajasthan (excluding NCR cities) showed marginal improvement of 2 per cent.

Delhi-NCR with average PM2.5 of 95 µg/m^3 was the most polluted sub-region of North India. It was followed by Haryana (excluding NCR cities) and Punjab with average PM2.5 of 79 µg/m^3 and 73 µg/m^3 respectively. Uttar Pradesh and Rajasthan were the least polluted sub-region with average PM2.5 of 62 µg/m^3 and 65 µg/m^3 respectively. This was the most polluted winter for Punjab in the last four years. But for all the other subregions this winter was one of their cleanest winter in the last four years.

Graph 3R2: Trend in winter PM2.5 levels among the sub-regions of North India



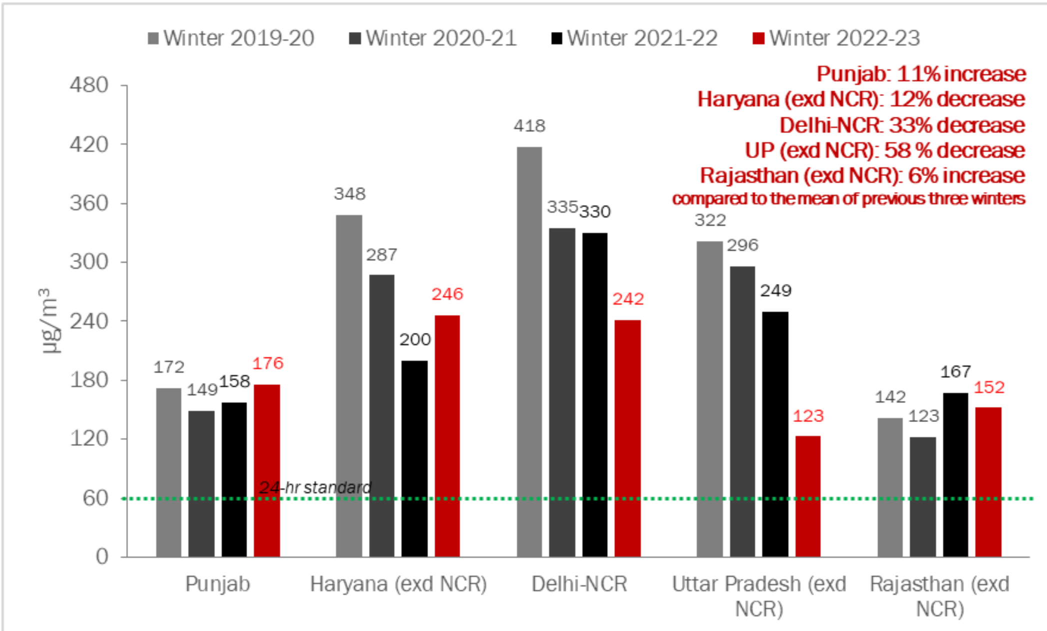
Note: Winter is defined as 1 October-28 February. Winter average is based on the mean of daily averages.
Source: CSE analysis of CPCB realtime data

Peak pollution continues to be a problem in all sub-regions of North India; Punjab and Rajasthan registered considerable spike in their peaks: Haryana (excluding NCR cities) and Delhi-NCR with peak PM2.5 of 246 µg/m^3 and 242 µg/m^3 had the worst short-term pollution episodes among the sub-regions of North India. Interestingly though, peaks in these two sub-regions were not on the same date. The peak for Haryana (excluding NCR cities) happened on 9 November 2022 while for Delhi-NCR the peak happened almost a week earlier on 3 November 2022. Punjab had its peak on 9 November 2022 as well but it was considerably lower at 176 µg/m^3. Uttar Pradesh (excluding NCR cities) and Rajasthan (excluding NCR cities) recorded their peak much earlier in the season and it coincided with Diwali (25 October 2022) and they were 123 µg/m^3 and 152 µg/m^3 respectively (See *Graph 3R3: Trend in winter PM2.5 peaks among the sub-regions of North India*).

Winter peak in Punjab was 11 per cent higher than the mean of previous three winter peaks. Similarly, the peak for Rajasthan (excluding NCR cities) was 6 per cent higher. Rest of the sub-regions recorded decline in peak levels. Delhi-NCR's winter peak this year was 33 per cent lower than the mean of previous three winters. Uttar Pradesh (excluding NCR cities) registered 58 per cent improvement in winter peak. Haryana (excluding NCR cities) peak shows 12 per cent improvement.

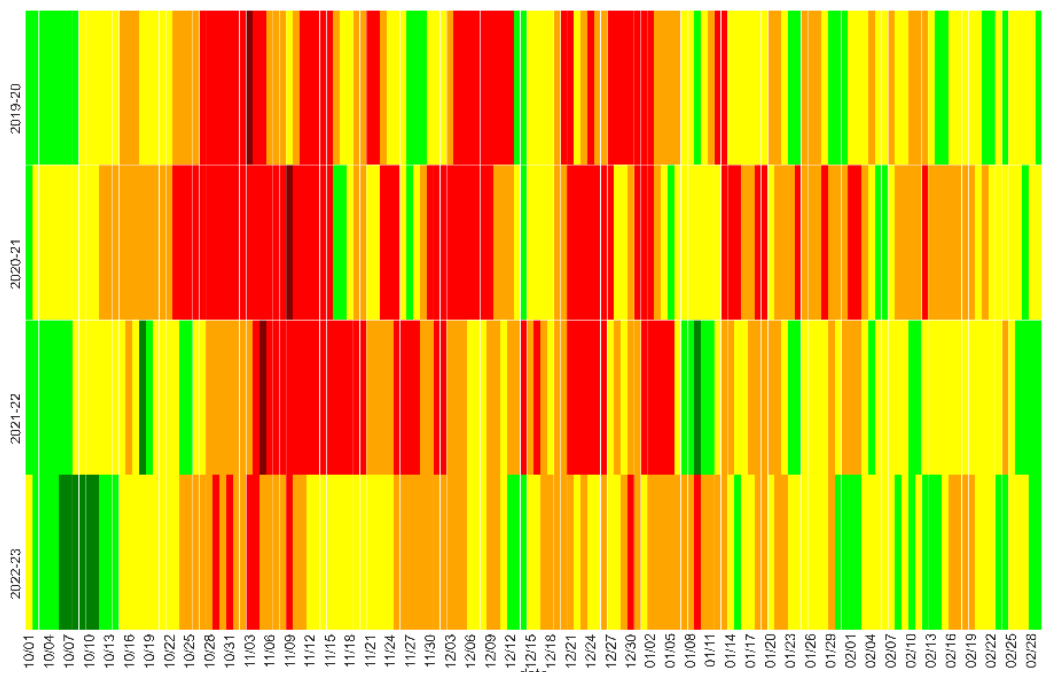
Only seven days with regional PM2.5 levels in "Very poor" AQI sub-category: Regional PM2.5 level crossed into "very poor" AQI category only on seven days this season so far. Previous years there were 35-56 "very poor" days during the same period. Further, these "very poor" days have not been contiguous as noted in previous years and this resulted in the first winter in the last four years where no regional smog episode occurred (See *Graph 3R4: Regional air quality calendar of North India*). But there have been smog episodes at city levels this winter but they have not been as strong as previous winters.

Graph 3R3: Trend in winter PM2.5 peaks among the sub-regions of North India



Note: Winter is defined as 1 October-28 February. Winter peak is based on the mean of daily averages of all cities in the subregion.
Source: CSE analysis of CPCB realtime data

Graph 3R4: Regional air quality calendar of North India



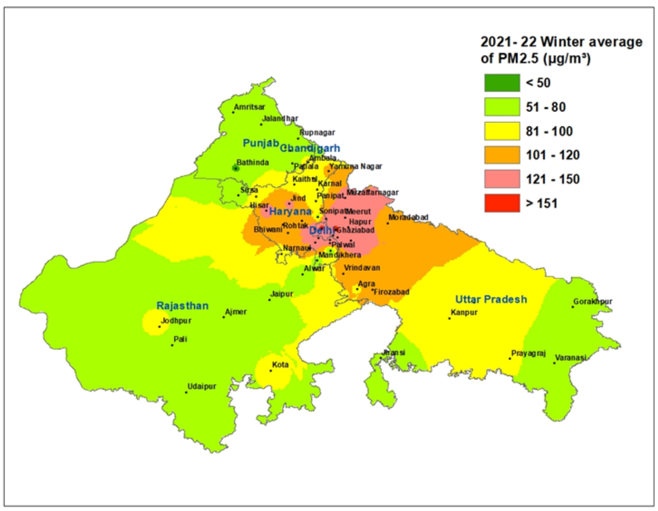
Note: 55 cities that constitute North India regional average are Agra, Ajmer, Alwar, Ambala, Amritsar, Baghpat, Bahadurgarh, Ballabgarh, Bhatinda, Bhiwadi, Bhiwani, Bulandshahr, Chandigarh, Charkhi Dadri, Delhi, Dharuhera, Faridabad, Fatehabad, Ghaziabad, Greater Noida, Gurugram, Hapur, Hisar, Jaipur, Jalandhar, Jind, Jodhpur, Kaithal, Kanpur, Karnal, Khanna, Kota, Kurukshetra, Lucknow, Ludhiana, Mandi Gobindgarh, Mandikhera, Manesar, Meerut, Moradabad, Muzaffarnagar, Narnaul, Noida, Pali, Palwal, Panchkula, Panipat, Patiala, Rohtak, Rupnagar, Sirsa, Sonipat, Udaipur, Varanasi, and Yamuna Nagar. Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB realtime data

<u>Winter air quality is a pan North India problem with Delhi-NCR being its epicentre</u>: Rise of winter air pollution level is synchronised across North India but its intensity varies geographically. Delhi-NCR is the epicentre of regional blanket of poor air with the PM2.5 concentration gradually declining as one moves away from Delhi-NCR in any direction (See *Map 3R1: Spatial distribution of PM2.5 over North India: a) 2021-22 winter; b) 2022-23 winter*).

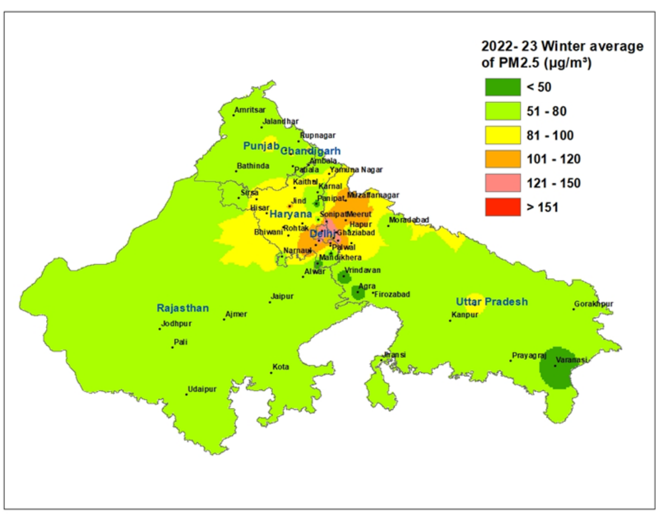
This season the overall PM2.5 levels have remained relatively low but the spatial distribution remains similar to previous winters. Worsening of air quality starts mid-October across North India in a synchronised fashion as weather starts to cool down and winds lose speed. The first peak is recorded in early November after which PM2.5 levels plateau for over a month. A second peak occurs around new year and then the PM2.5 starts ebbing away to moderate to satisfactory levels by the end of February. This winter repeated the same temporal pattern but with less magnitude (See *Graph 3R5: Air quality heatmap of North Indian cities*).

Map 3R1: Spatial distribution of PM2.5 over North India

a) 2021-22 winter



b) 2022-23 winter



Note: Winter is defined as 1 October-28 February. Winter average is based on the mean of daily averages.
Source: CSE analysis of CPCB realtime data

Graph 3R5: Air quality heatmap of North Indian cities

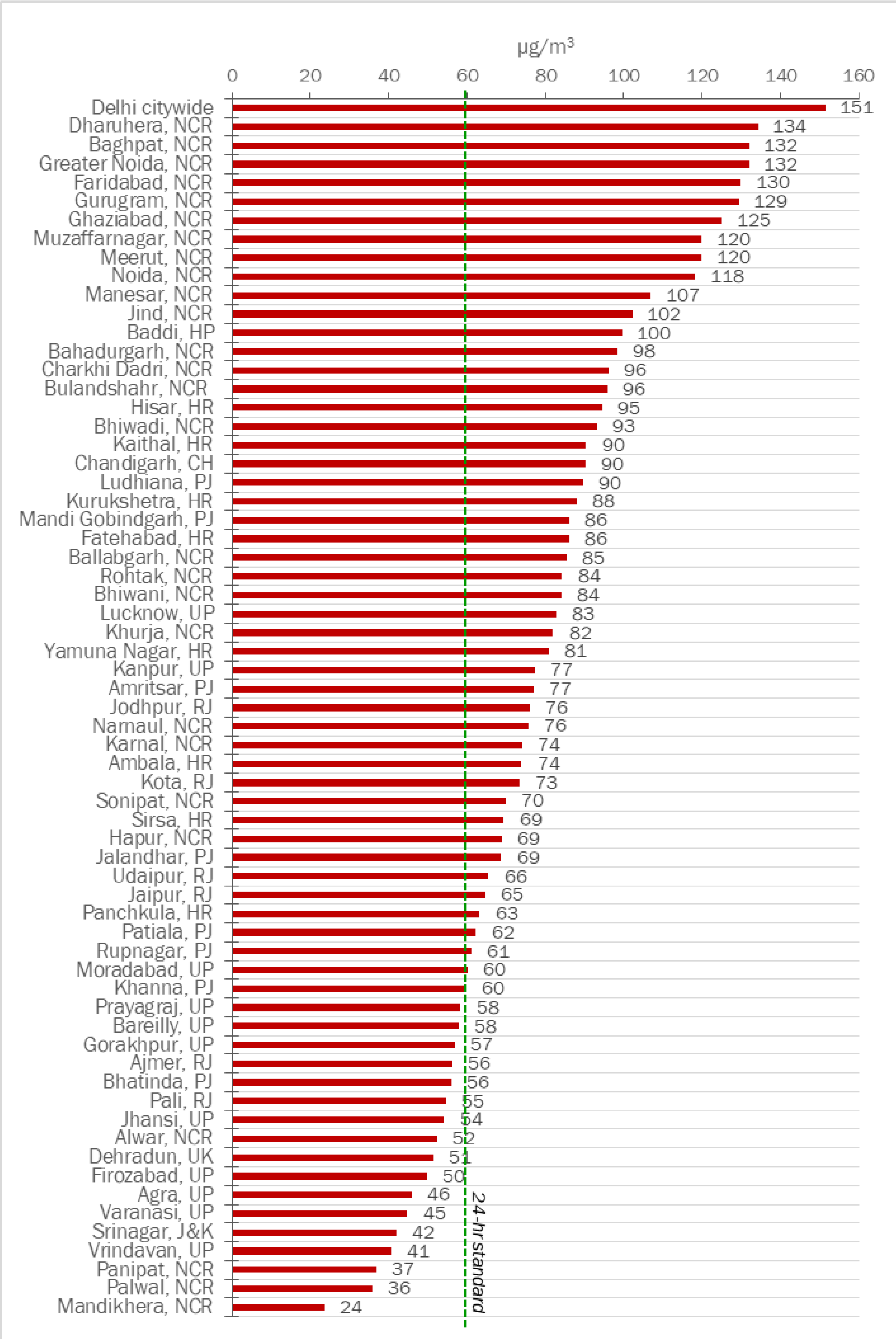
Note: Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB realtime data

Smaller cities as polluted as Delhi: Delhi was the most polluted city in North India with average PM2.5 of 151 µg/m^3 but smaller towns like Dharuhera, HR and Baghpat, UP (both part of NCR) were almost as polluted as Delhi with PM2.5 average of 134 µg/m^3 and 132 µg/m^3 respectively (See *Graph 3R6: Winter PM2.5 level among North Indian).*

Outside NCR, Baddi in Himachal Pradesh was the most polluted with PM2.5 average of 100 µg/m^3 followed by Haryanvi towns of Hisar (95 µg/m^3) and Kaithal (90 µg/m^3). Chandigarh registered a very high winter average of 90 µg/m^3 as well. Ludhiana with PM2.5 average of 90 µg/m^3 was the most polluted city in Punjab followed by Mandi Gobindgarh (86 µg/m3). Lucknow with PM2.5 average of 83 µg/m^3 was the most polluted city in UP (excluding NCR cities) followed by Kanpur (77 µg/m^3). Jodhpur with PM2.5 average of 76 µg/m^3 was the most polluted city in Rajasthan (excluding NCR cities) followed by Kota (73 µg/m^3).

Haryanvi towns of Mandikhera and Palwal (both are part of NCR) were the least polluted towns in North India with PM2.5 average of 24 µg/m^3 and 36 µg/m^3. Panipat, HR (37 µg/m^3); Vrindavan, UP (41 µg/m^3); and Srinagar, J&K (42 µg/m^3) were other low pollution towns.

Graph 3R6: Winter PM2.5 level among North Indian cities



Note: Winter is defined as 1 October-28 February. Winter peak is based on the mean of daily averages. Cities with multiple stations are represented by the mean of all city stations.

Source: CSE analysis of CPCB realtime data

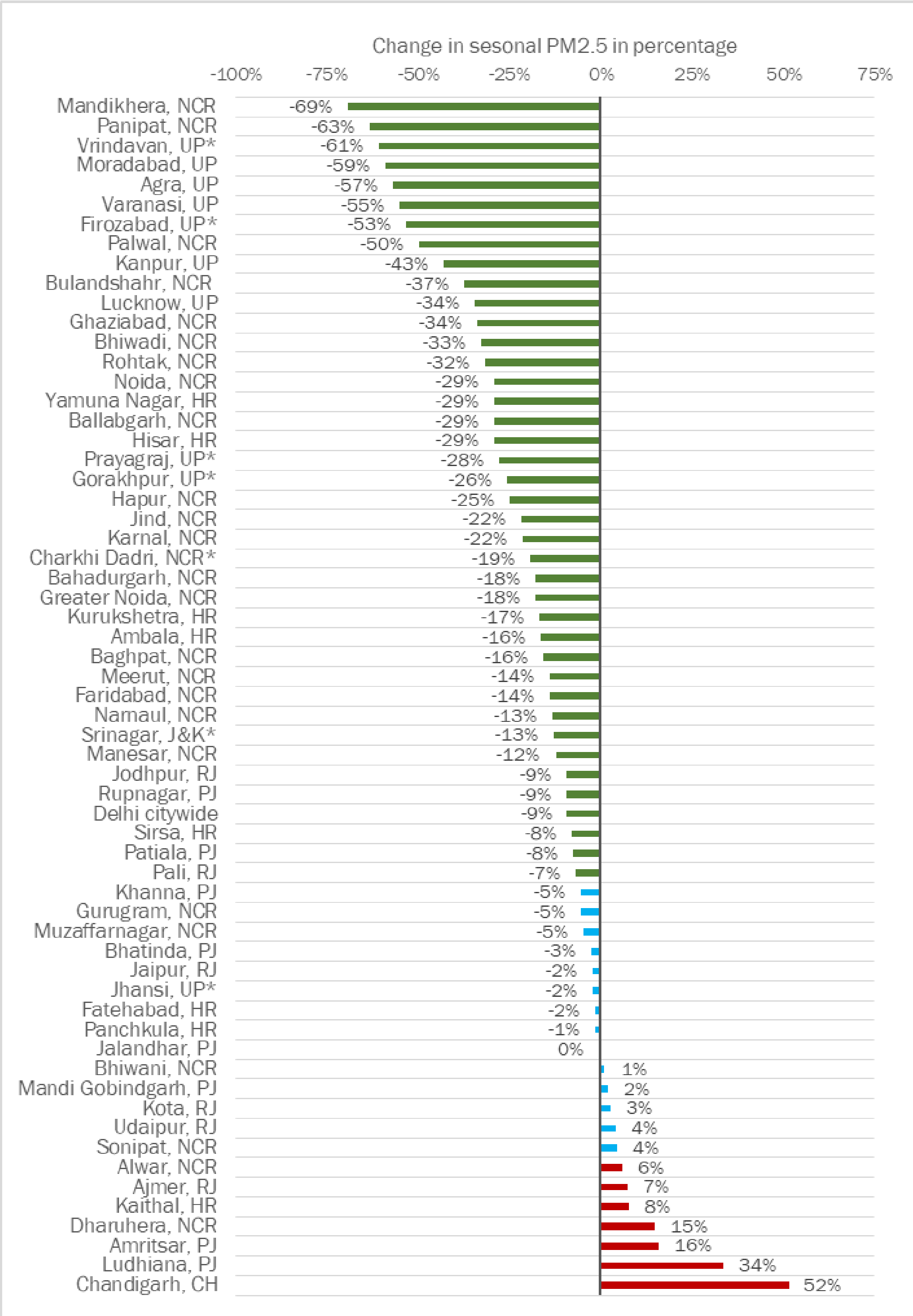
Chandigarh registered an increase in pollution this year bucking the larger regional trend: Most cities and towns have shown improvement in air quality this season compared to the same period previous year. Mandikhera and Panipat registered the most improvement with 69 per cent and 63 per cent lower PM2.5 compared to the mean of previous three winters (See *Graph 3R7: Winter PM2.5 level among North Indian cities*). Chandigarh was the worst performer and registered an increase of 52 per cent from last year. Dharuhera, HR; Amritsar, PJ and Ludhiana, PJ also registered over 15 per cent increase in pollution level this season compared to previous three seasons.

Most polluted locations in North India are located within Delhi's city limits: Nehru Nagar in Delhi has been the most polluted location in North India with PM2.5 average of 195 µg/m^3. Jahangirpuri, Anand Vihar, Lodhi Road (IITM), Vivek Vihar, Wazirpur Mundka, Patparganj, NSIT Dwarka and Shadipur round up the top ten most polluted locations in North India and all are located within Delhi (See *Annexure 3R: Winter PM2.5 level at station levels among North Indian cities*). In fact, the only non-Delhi station in top 20 most polluted locations in North India is Faridabad's Sector 16A which has a winter average of 164 µg/m^3. Mandikhera and Palwal in south Haryana were the least polluted locations in North India.

Increasing levels of Nitrogen dioxide (NO2) during November: There is a significant increase in the amount of NO2 in air during November compared to October and September. NO2 comes entirely from combustion sources and significantly from vehicles. UP cities (outside NCR) have registered the greatest increase of 2.9 times maximum build-up of NO2 between September and November. Punjab and Haryana cities have registered 1.5 times increase while NCR and Rajasthan cities saw 1.7 times jump in sub-regional NO2 from September to November (See *Graph 3R8: Trend in NO2 levels among sub-regions of North India*).

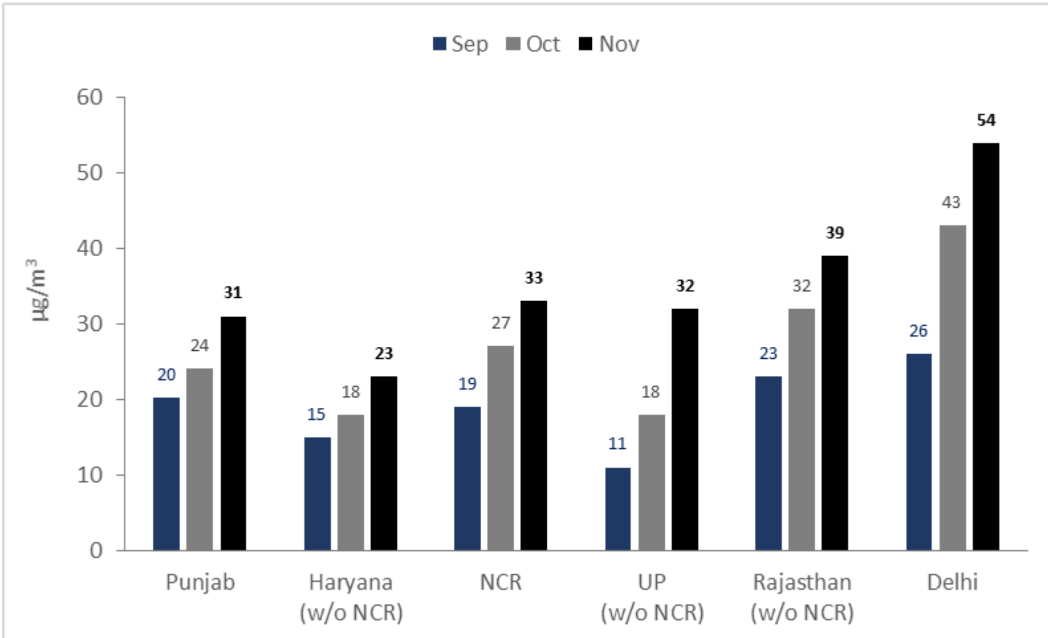
In absolute concentration terms, Rajasthan cities (outside NCR) registered the highest sub-regional average of 39 µg/m^3 (See *Graph 3R9: November NO2 levels among sub-regions of North India*). Among NCR cities Ghaziabad with a monthly average of 90 µg/m^3 was the most polluted in the region. Chandigarh (44 µg/m^3) in Punjab, Kurukshetra (50 µg/m^3) in Haryana, Firozabad (54 µg/m^3) in UP, and Jaipur (68 µg/m^3) in Rajasthan were the most polluted with NO2 in each of the sub-regions.

Graph 3R7: Change in winter PM2.5 level among North Indian cities



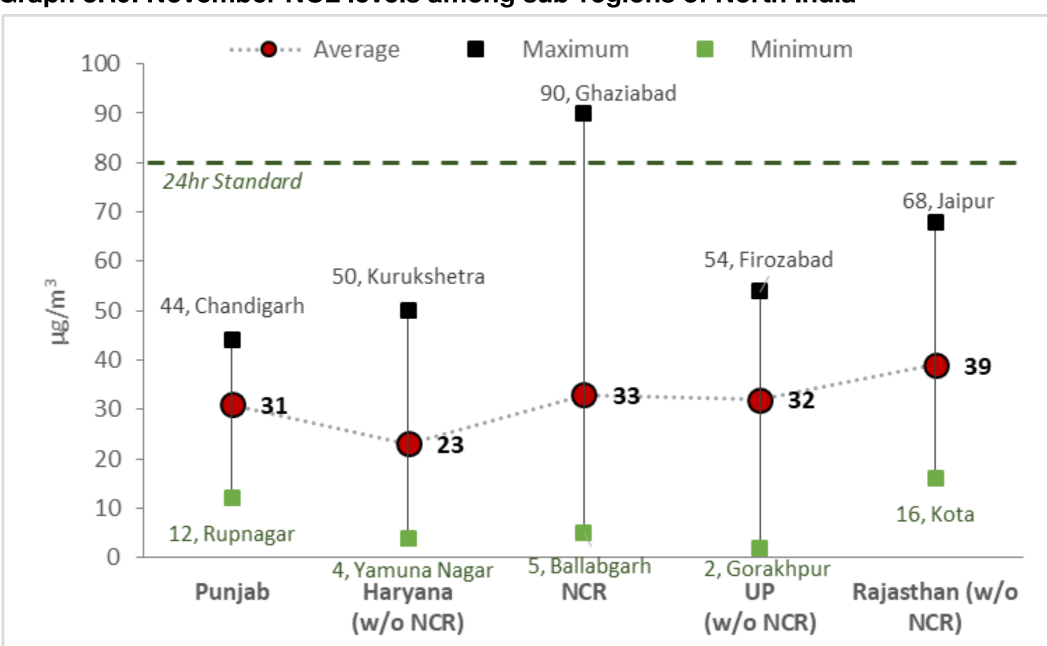
Note: Winter is defined as 1 October-28 February. Winter peak is based on the mean of daily averages. Cities with multiple stations are represented by the mean of all city stations. Winter average of a city is compared to the mean of the previous three winters. For cities that don't have data for all three previous winters but have at least complete data for 2021-22 winter comparison is reported with available data but the result is flagged off with *.
Source: CSE analysis of CPCB realtime data

Graph 3R8: Trend in NO2 levels among sub-regions of North India



Note: NO2 values for sub-regions are based on the average of citywide values of all the cities in that region. NO2 values for cities with more than one monitoring station is based on the average of all stations that have continuous and adequate data for complete assessment period. Data up till 30 November 2022.
Source: CSE analysis of real-time data from CPCB portal

Graph 3R9: November NO2 levels among sub-regions of North India



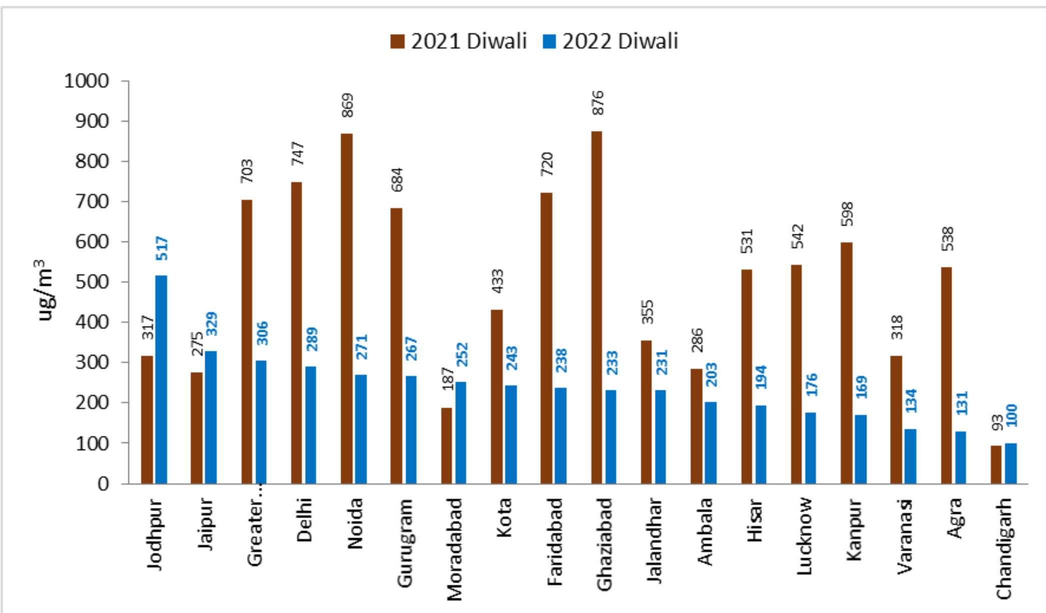
Note: NO2 values for sub-regions are based on the average of citywide values of all the cities in that region. NO2 values for cities with more than one monitoring station is based on the average of all stations that have continuous and adequate data for complete assessment period. Data up till 30 November 2022.
Source: CSE analysis of real-time data from CPCB portal

Diwali pollution is highest among cities of Rajasthan in Northern Region: Pollution level on Diwali night (8pm to 8am) in cities shot up by 0.8 – 5.5 times the average level recorded seven nights preceding Diwali (See *Graph 3R11: Diwali night pollution among cities of North India*). Jaipur saw the greatest jump of 5.5 times higher PM2.5 level on Diwali night followed by Jodhpur with 4.4 times higher PM2.5 concentration at 517 µg/m^3.

While Delhi at 289 µg/m^3 saw a 61 per cent decline from last year's Diwali night when it was 747µg/m^3. Outside NCR, Rajasthan cities dominate in the top 10 list of most polluted Diwali nights. Kota and Ajmer topped the list with Diwali night PM2.5 levels recording levels as high as 243 µg/m^3 and 239 µg/m^3 respectively. Ludhiana in Punjab, Kurukshetra in North Haryana and Moradabad in UP also feature in the top ten. Bhatinda at 43 µg/m^3 had the least polluted Diwali night in the region followed by Vrindavan at 53 µg/m^3.

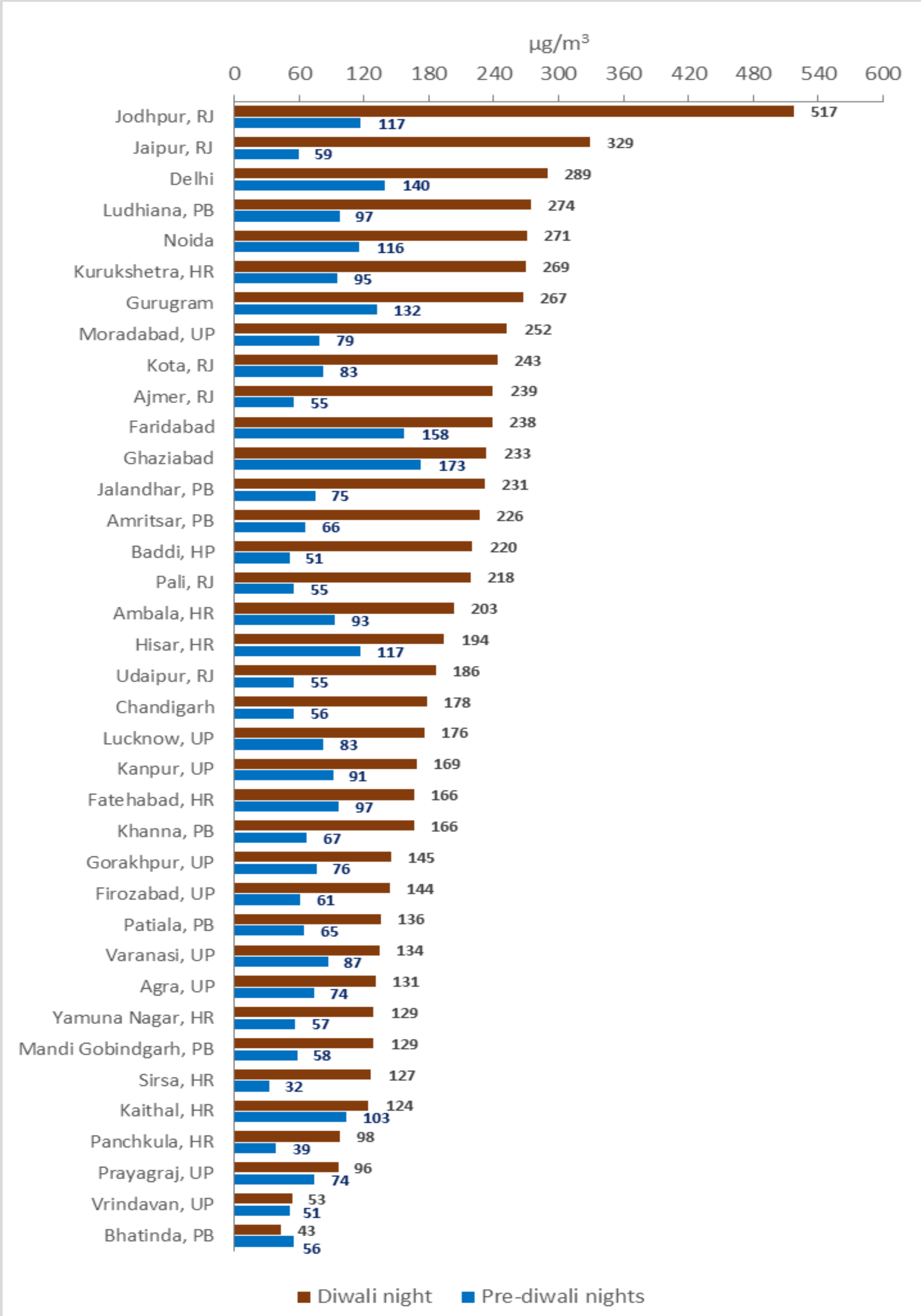
This Diwali is least polluted compared to last year's Diwali for all major cities in the region except Jodhpur, Jaipur, Moradabad and Chandigarh. Cities of Rajasthan had seen the maximum increase on Diwali night (See *Graph 3R10: Trend in Diwali night pollution among major cities of North India*).

Graph 3R10: Trend in Diwali night pollution among major cities of North India



Note: PM2.5 values for cities with more than one monitoring station is based on average of all stations that have continuous and adequate data for complete assessment period. Diwali night is considered from 8.00PM to 8.00AM on 4 November 2021 and 24 October 2022.
Source: CSE analysis of real-time data from CPCB portal

Graph 3R11: Trend in Diwali night pollution among major cities of North India



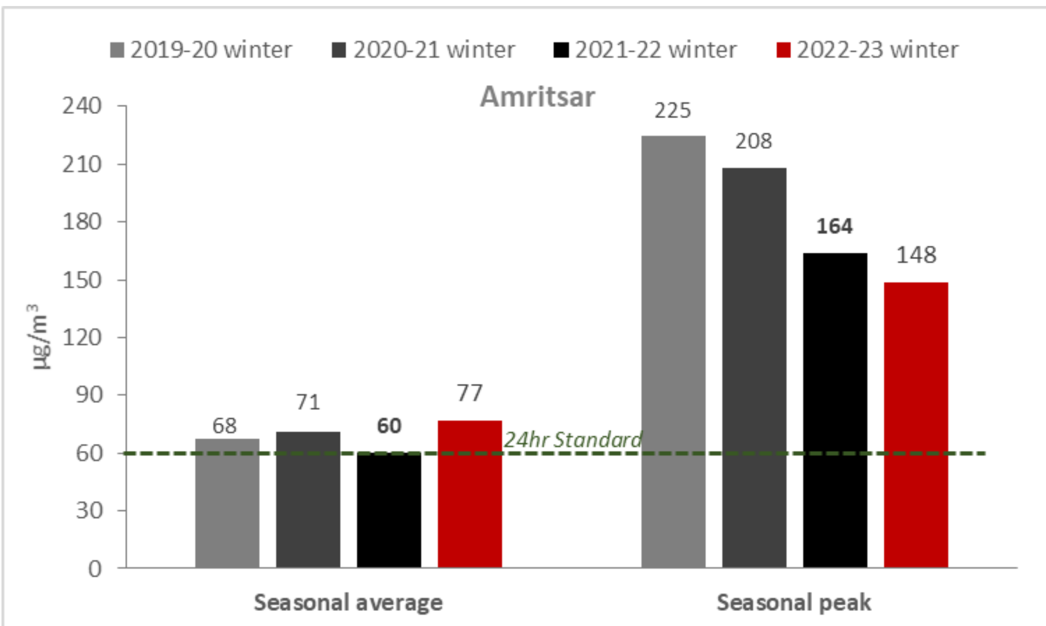
Note: PM2.5 values for cities with more than one monitoring station is based on average of all stations that have continuous and adequate data for complete assessment period. Diwali night is considered from 8.00PM October 24 to 8.00AM October 25. Pre-diwali night is an average of seven nights (8.00PM-8.00AM) preceding Diwali.

Key findings: Cities

Note: This does not include Delhi, Gurugram, Faridabad, Nodia and Ghaziabad as these have been covered in the Delhi-NCR analysis that can be found in Report 11.

Punjab: Amritsar
Average PM2.5 pollution level during this winter has been 77 µg/m³ in Amritsar, which is 28 per cent higher than the 24-hr standard. The level has been rising as well with this winter level being 16 per cent higher than the mean of previous three winters (See *Graph 3R12: PM2.5 winter trend in Amritsar*). Despite rising average pollution levels the city is registering a continuous drop in its seasonal peak. This winter the peak stood at 148 µg/m³, which is almost 2.5-times the 24-hr standard, yet 25 per cent lower than the mean of previous three winter peaks.

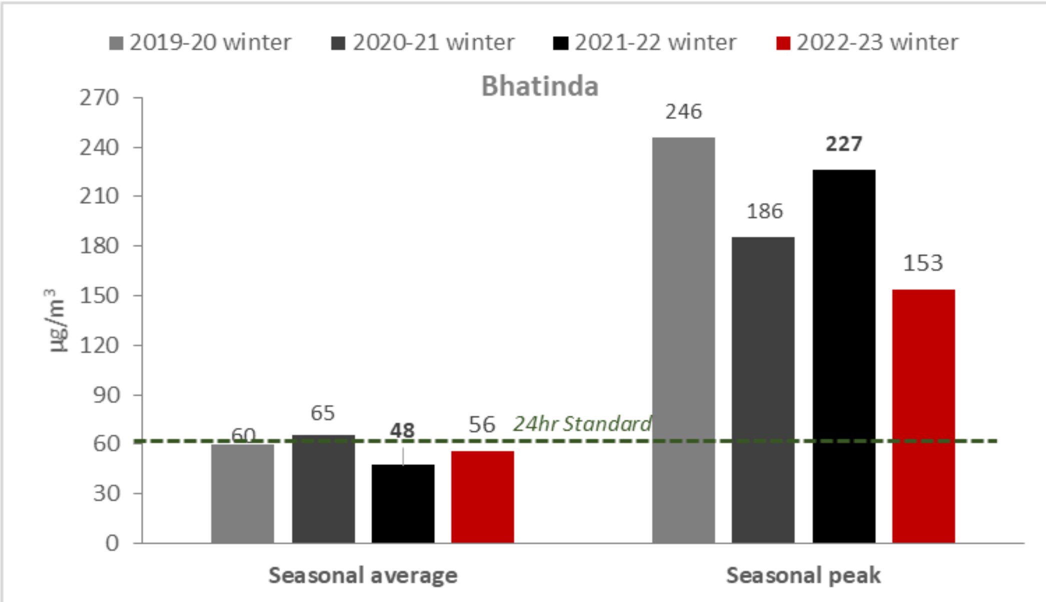
Graph 3R12: PM2.5 winter trend in Amritsar



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Punjab: Bhatinda
Average PM2.5 pollution level during this winter has been 56 µg/m³ in Bhatinda, which is just under the 24-hr standard. The level has been stable in the city over years with this winter level being 3 per cent lower than the mean of previous three winters (See *Graph 3R13: PM2.5 winter trend in Bhatinda*). The city is registering a continuous drop in its seasonal peak as well. This winter the peak stood at 153 µg/m³, which is almost 2.5-times the 24-hr standard, yet 30 per cent lower than the mean of previous three winter peaks.

Graph 3R13: PM2.5 winter trend in Bhatinda

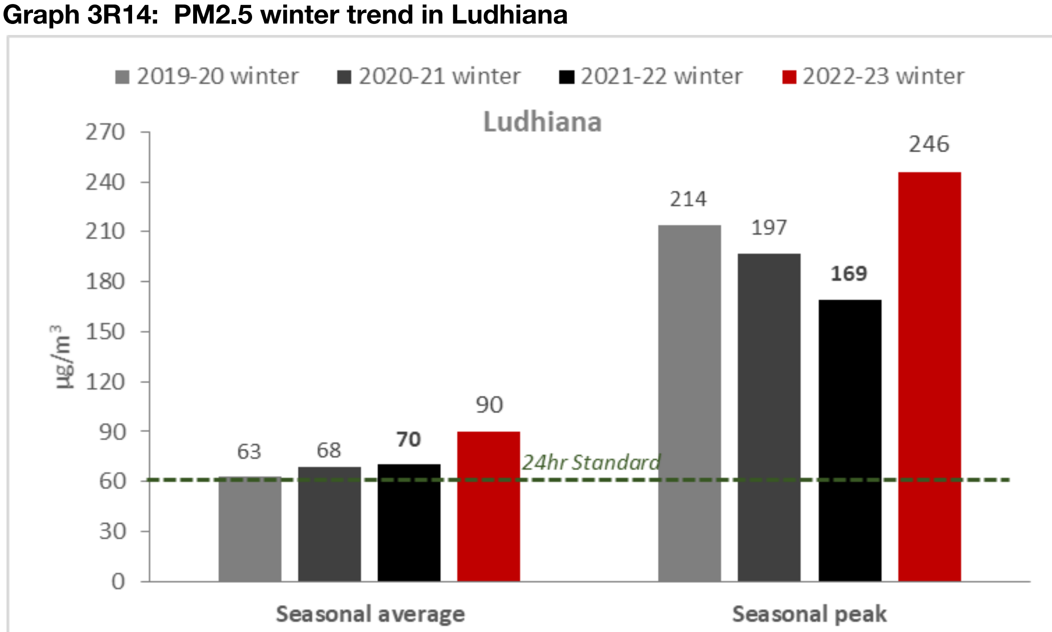


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Punjab: Ludhiana

Average PM2.5 pollution level during this winter has been 90 µg/m^3 in Ludhiana, which is 50 per cent higher than the 24-hr standard. The level has been rising in the city over years with this winter level being 34 per cent higher than the mean of previous three winters (See *Graph 3R14: PM2.5 winter trend in Ludhiana*). The city is registering a spike in its seasonal peak as well. This winter the peak stood at 246 µg/m^3, which is over 4-times the 24-hr standard, and 27 per cent higher than the mean of previous three winter peaks.

Graph 3R14: PM2.5 winter trend in Ludhiana

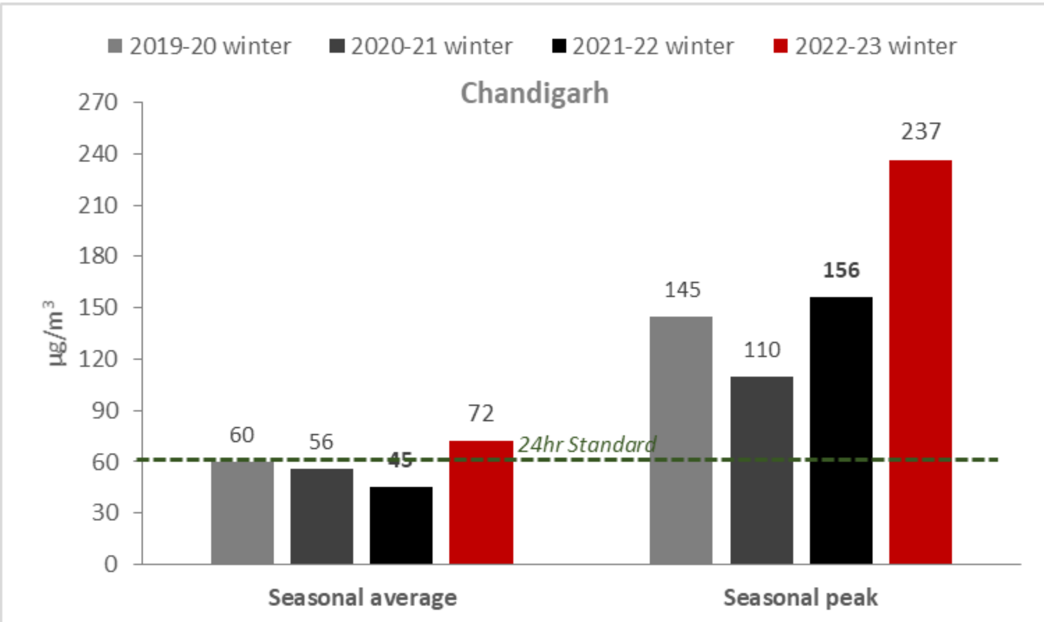


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Chandigarh: Chandigarh

Average PM2.5 pollution level during this winter has been 72 µg/m^3 in Chandigarh, which is 21 per cent higher than the 24-hr standard. The level had been declining in the city over the previous three years but this winter level spiked and is 35 per cent higher than the mean of previous three winters (See *Graph 3R15: PM2.5 winter trend in Chandigarh*). The city is registering a spike in its seasonal peak as well. This winter the peak stood at 237 µg/m^3, which is almost 4-times the 24-hr standard, and 73 per cent higher than the mean of previous three winter peaks.

Graph 3R15: PM2.5 winter trend in Chandigarh

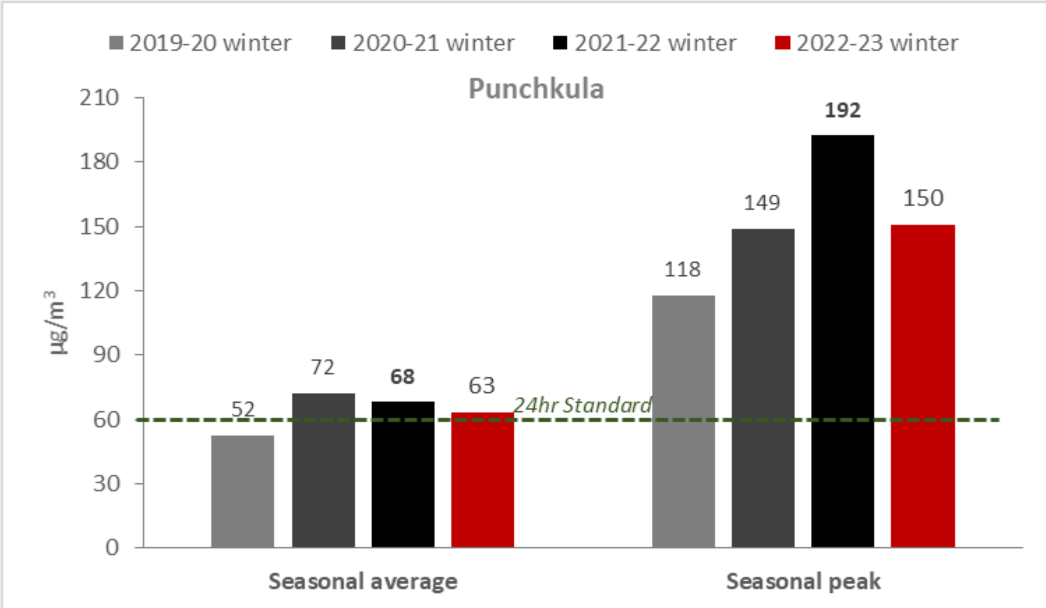


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Haryana: Panchkula

Average PM2.5 pollution level during this winter has been 63 µg/m^3 in Panchkula, which is 5 per cent higher than the 24-hr standard. The level has been stable in the city over years and this winter level is just 1 per cent lower than the mean of previous three winters (See *Graph 3R16: PM2.5 winter trend in Panchkula*). The city is registering a drop in its seasonal peak this winter bending the rising trend noted in previous three winters. This winter the peak stood at 150 µg/m^3, which is 2.5-times the 24-hr standard, and 2 per cent lower than the mean of previous three winter peaks.

Graph 3R16: PM2.5 winter trend in Panchkula

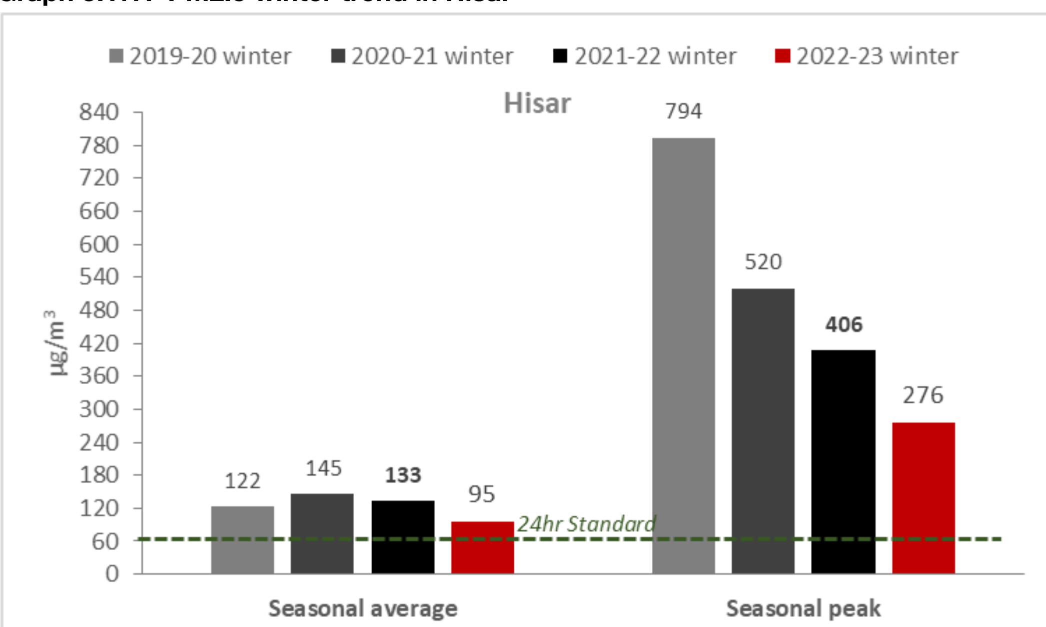


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Haryana: Hisar

Average PM2.5 pollution level during this winter has been 95 µg/m^3 in Hisar, which is 58 per cent higher than the 24-hr standard. The level has been declining in the city over years and this winter level is 29 per cent lower than the mean of previous three winters (See *Graph 3R17: PM2.5 winter trend in Hisar*). The city is registering a drop in its seasonal peaks over years. This winter the peak stood at 276 µg/m^3, which is 4.5-times the 24-hr standard, and 52 per cent lower than the mean of previous 3 winter peaks.

Graph 3R17: PM2.5 winter trend in Hisar

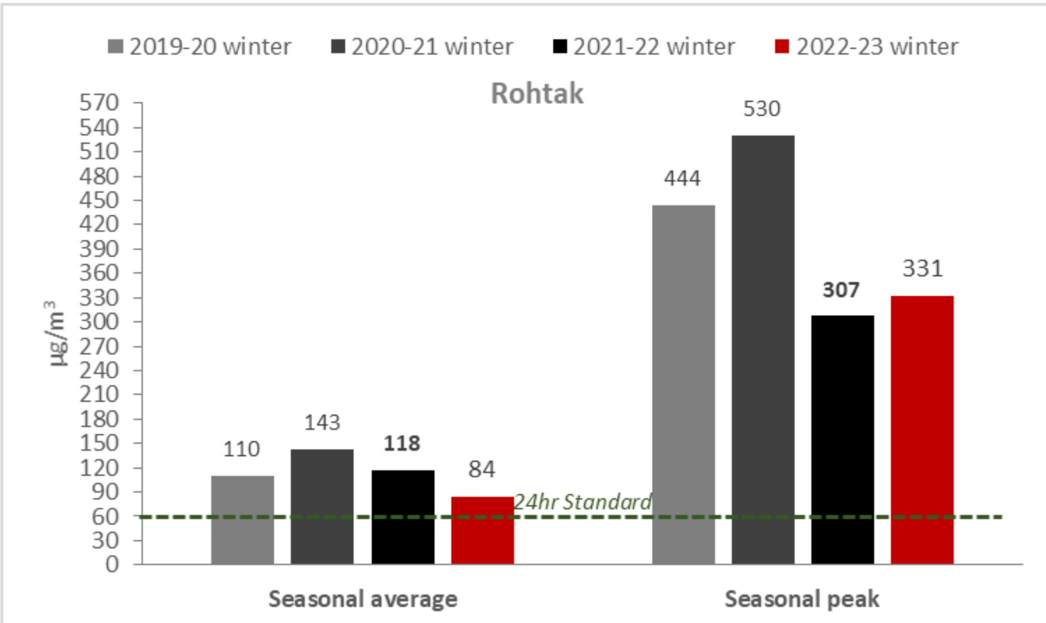


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Haryana: Rohtak

Average PM2.5 pollution level during this winter has been 84 µg/m³ in Rohtak, which is 40 per cent higher than the 24-hr standard. The level has been declining in the city over years and this winter level is 32 per cent lower than the mean of previous three winters (See *Graph 3R18: PM2.5 winter trend in Rohtak*). The city's seasonal peaks over years have shown no defined trend with this winter peak being marginally higher than previous winter but much lower than the peaks of 2019-20 and 2020-21 winters. This winter the peak stood at 331 µg/m³, which is 5.5-times the 24-hr standard, and 22 per cent lower than the mean of previous three winter peaks.

Graph 3R18: PM2.5 winter trend in Rohtak

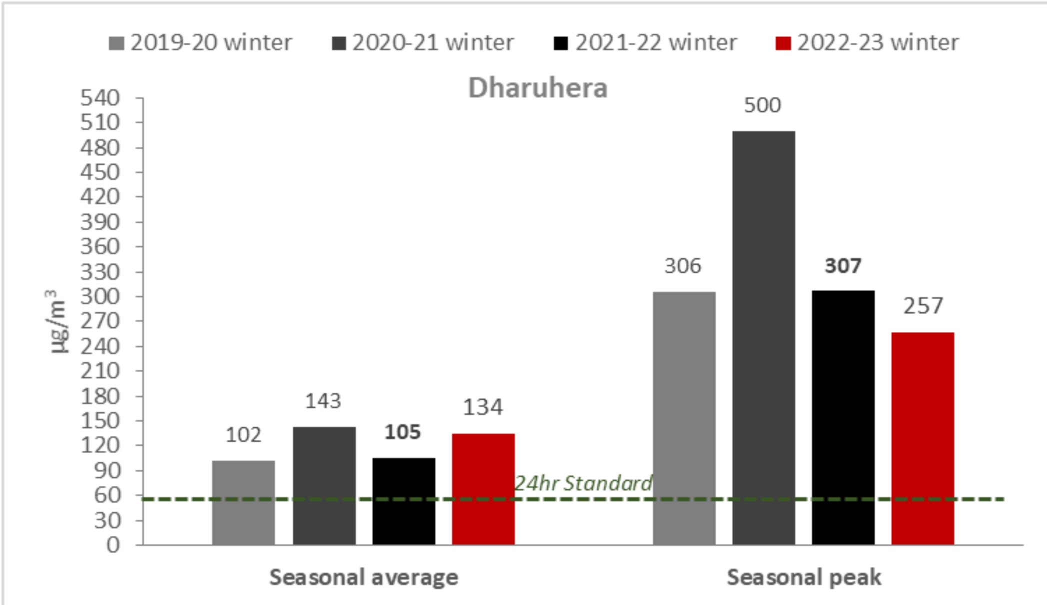


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Haryana: Dharuhera

Average PM2.5 pollution level during this winter has been 134 µg/m³ in Dharuhera, which is 124 per cent higher than the 24-hr standard. The level has shown no defined trend in the city over years and this winter level is 15 per cent higher than the mean of previous three winters (See *Graph 3R19: PM2.5 winter trend in Dharuhera*). The city's seasonal peaks over years have shown a declining trend. This winter the peak stood at 257 µg/m³, which is over 4-times the 24-hr standard, and 31 per cent lower than the mean of previous three winter peaks.

Graph 3R19: PM2.5 winter trend in Dharuhera

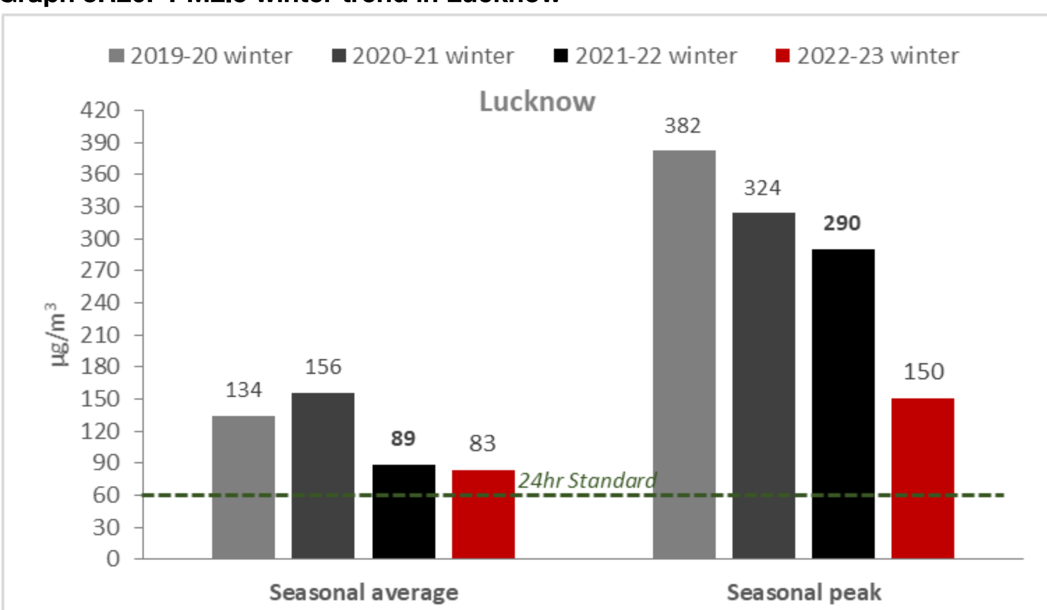


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Uttar Pradesh: Lucknow

Average PM2.5 pollution level during this winter has been 83 µg/m³ in Lucknow, which is 38 per cent higher than the 24-hr standard. The level has shown a declining trend in the city over years and this winter level is 34 per cent lower than the mean of previous three winters (See *Graph 3R20: PM2.5 winter trend in Lucknow*). The city's seasonal peaks over years have shown a declining trend. This winter the peak stood at 150 µg/m³, which is 2.5-times the 24-hr standard, and 55 per cent lower than the mean of previous three winter peaks.

Graph 3R20: PM2.5 winter trend in Lucknow

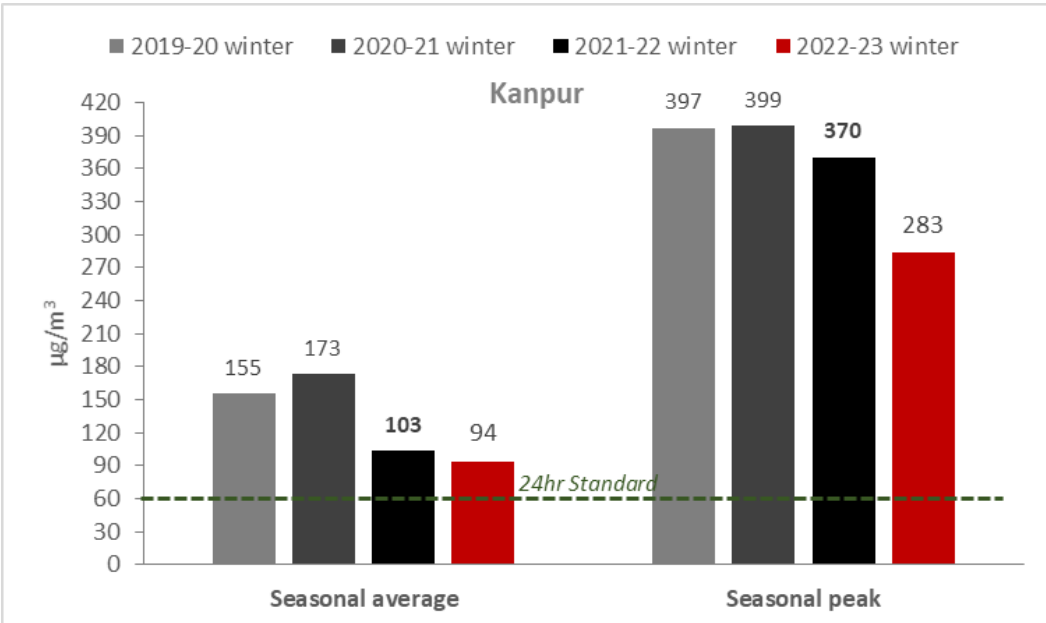


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Uttar Pradesh: Kanpur

Average PM2.5 pollution level during this winter has been 94 µg/m³ in Kanpur, which is 57 per cent higher than the 24-hr standard. The level has shown a declining trend in the city over years and this winter level is 35 per cent lower than the mean of previous three winters (See *Graph 3R21: PM2.5 winter trend in Kanpur*). The city's seasonal peaks over years have shown a declining trend. This winter the peak stood at 283 µg/m³, which is over 4.5-times the 24-hr standard, and 27 per cent lower than the mean of previous three winter peaks.

Graph 3R21: PM2.5 winter trend in Kanpur

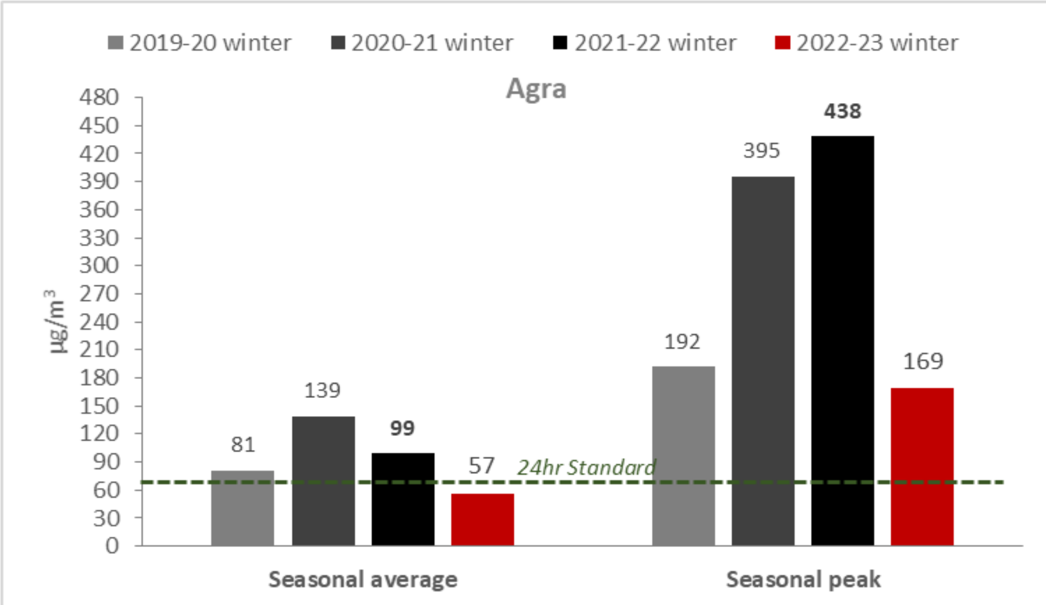


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Uttar Pradesh: Agra

Average PM2.5 pollution level during this winter has been 57 µg/m³ in Agra, which is just under the 24-hr standard. The level has shown a declining trend in the city over years and this winter level is 47 per cent lower than the mean of previous three winters (See *Graph 3R22: PM2.5 winter trend in Agra*). The city has registered a drop in its seasonal peak this winter bending the rising trend noted in previous three winters. This winter the peak stood at 169 µg/m³ which is almost 3-times the 24-hr standard, and 50 per cent lower than the mean of previous three winter peaks.

Graph 3R22: PM2.5 winter trend in Agra

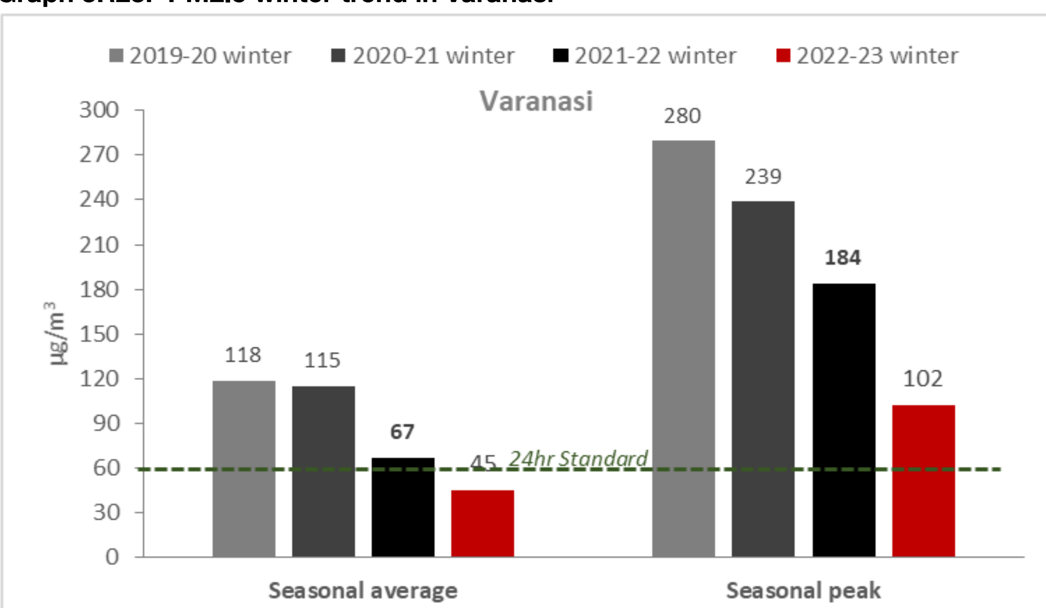


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Uttar Pradesh: Varanasi

Average PM2.5 pollution level during this winter has been 45 µg/m^3 in Varanasi, which is under the 24-hr standard. The level has shown a declining trend in the city over years and this winter level is 55 per cent lower than the mean of previous three winters (See *Graph 3R23: PM2.5 winter trend in Varanasi*). The city's seasonal peak exhibits a declining trend over winters. This winter the peak stood at 102 µg/m^3, which is 70 per cent higher than the 24-hr standard, and 56 per cent lower than the mean of previous three winter peaks.

Graph 3R23: PM2.5 winter trend in Varanasi

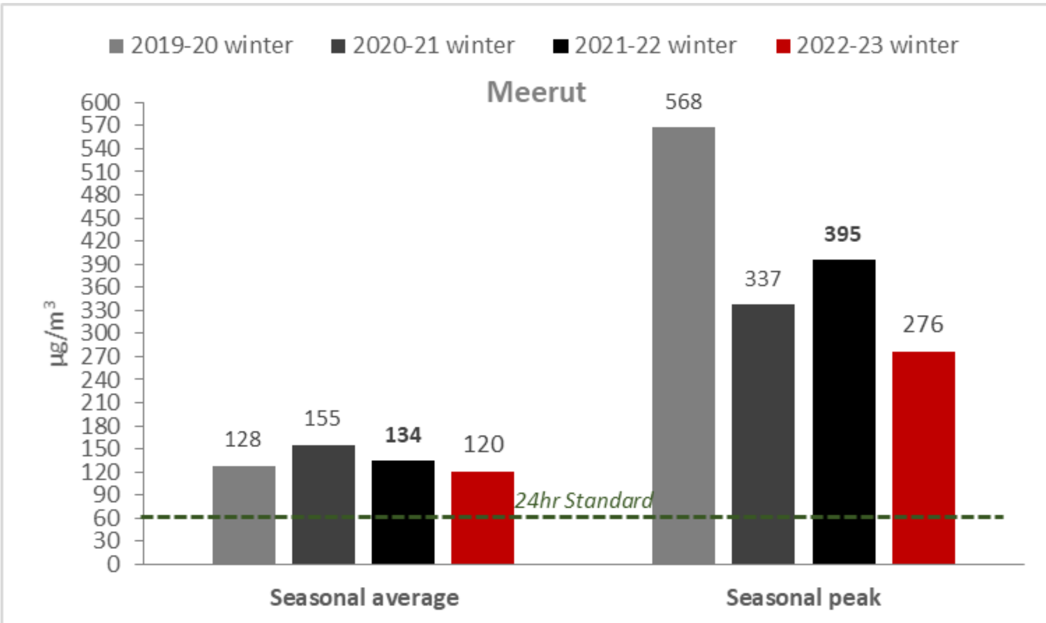


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Uttar Pradesh: Meerut

Average PM2.5 pollution level during this winter has been 120 µg/m^3 in Meerut, which is double the 24-hr standard. The level has shown a declining trend in the city over years and this winter level is 14 per cent lower than the mean of previous three winters (See *Graph 3R24: PM2.5 winter trend in Meerut*). The city's seasonal peak exhibits no definite trend over winters. This winter the peak stood at 276 µg/m^3, which is over 4.5 times the 24-hr standard, and 36 per cent lower than the mean of previous three winter peaks.

Graph 3R24: PM2.5 winter trend in Meerut

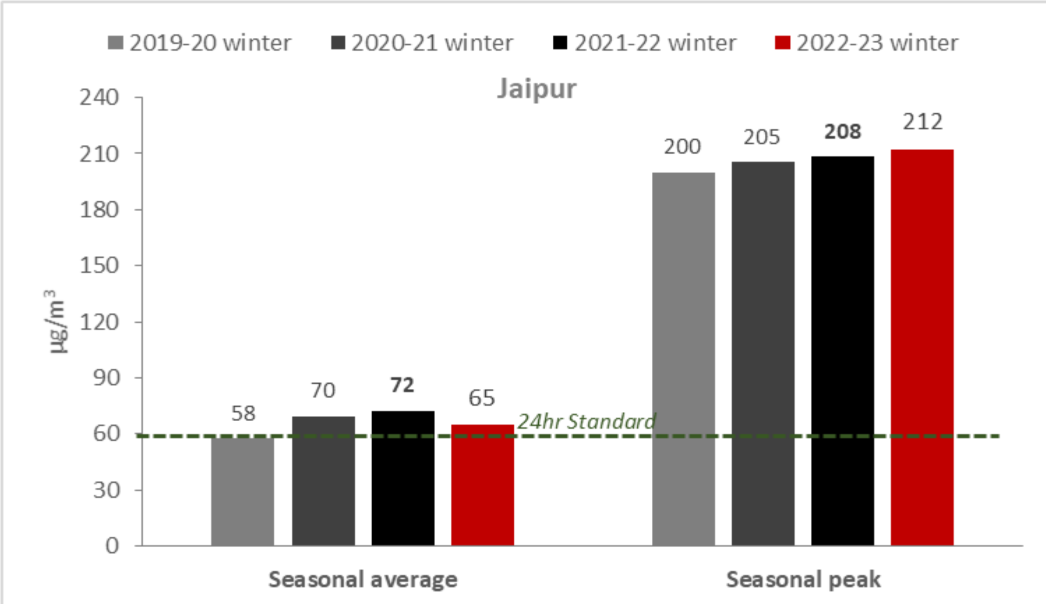


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Rajasthan: Jaipur

Average PM2.5 pollution level during this winter has been 65 µg/m^3 in Jaipur, which is 8 per cent higher than the 24-hr standard. The level had been rising in the city over the previous three winters but this winter the level has dropped and is 2 per cent lower than the mean of previous three winters (See *Graph 3R25: PM2.5 winter trend in Jaipur*). The city's seasonal peak exhibits a rising trend over winters. This winter the peak stood at 212 µg/m^3, which is over 3.5 times the 24-hr standard, and 4 per cent higher than the mean of previous three winter peaks.

Graph 3R25: PM2.5 winter trend in Jaipur

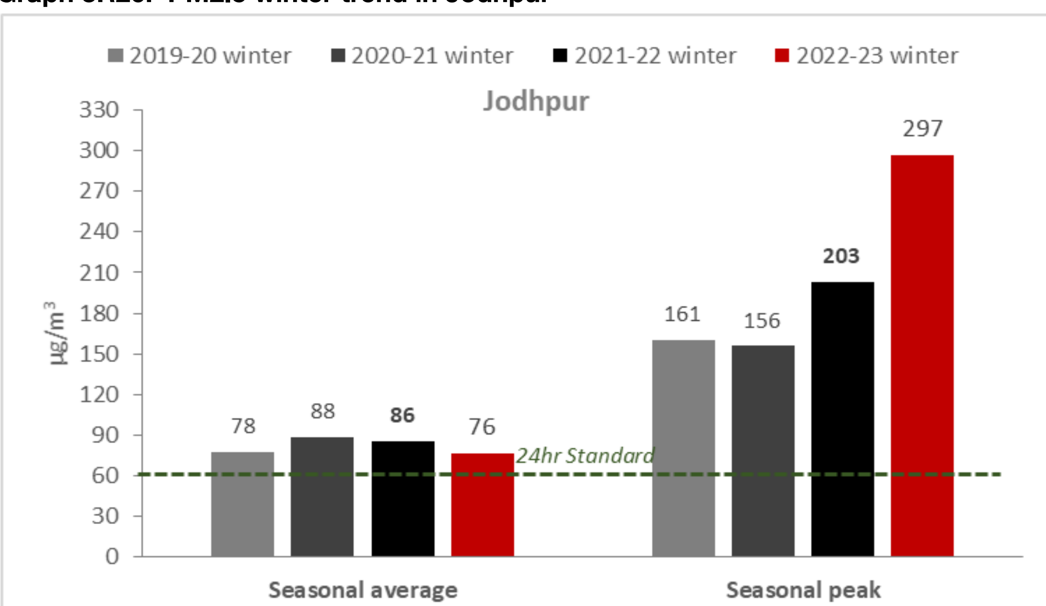


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Rajasthan: Jodhpur

Average PM2.5 pollution level during this winter has been 76 µg/m^3 in Jodhpur, which is 27 per cent higher than the 24-hr standard. The level had been stable in the city over winters and this winter the level is 9 per cent lower than the mean of previous three winters (See *Graph 3R26: PM2.5 winter trend in Jodhpur*). The city's seasonal peak exhibits a rising trend over winters. This winter the peak stood at 297 µg/m^3, which is about 5 times the 24-hr standard, and 71 per cent higher than the mean of previous three winter peaks.

Graph 3R26: PM2.5 winter trend in Jodhpur

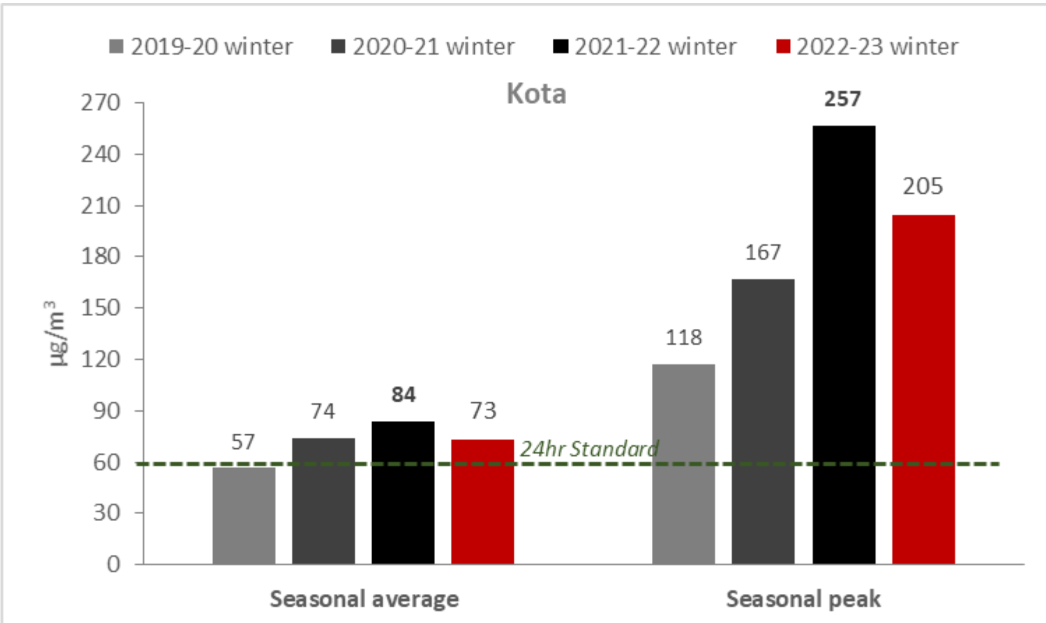


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Rajasthan: Kota

Average PM2.5 pollution level during this winter has been 73 µg/m³ in Kota, which is 22 per cent higher than the 24-hr standard. The level had been stable in the city over winters and this winter the level is 3 per cent higher than the mean of previous three winters (See *Graph 3R26: PM2.5 winter trend in Jodhpur*). The city has registered a drop in its seasonal peak this winter bending the rising trend noted in previous three winters. This winter the peak stood at 205 µg/m³, which is about 3.5 times the 24-hr standard, and 13 per cent higher than the mean of previous three winter peaks.

Graph 3R26: PM2.5 winter trend in Kota

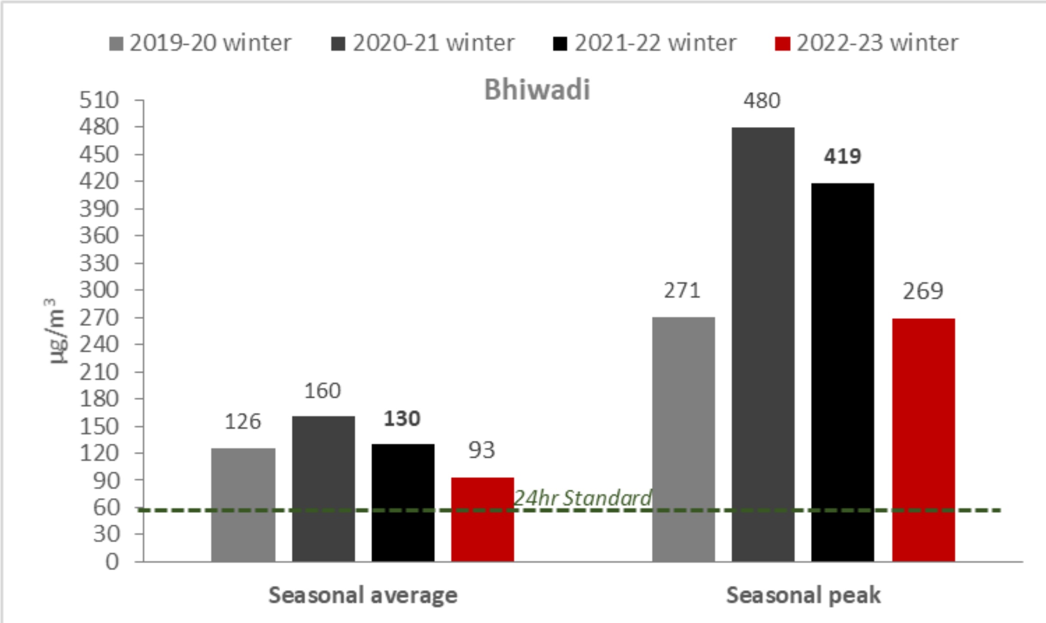


Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Rajasthan: Bhiwadi

Average PM2.5 pollution level during this winter has been 93 µg/m³ in Bhiwadi, which is 55 per cent higher than the 24-hr standard. The level had been declining in the city over winters and this winter the level is 33 per cent lower than the mean of previous three winters (See *Graph 3R26: PM2.5 winter trend in Jodhpur*). The city's seasonal peak exhibits a declining trend over winters. This winter the peak stood at 269 µg/m³, which is about 4.5 times the 24-hr standard, and 31 per cent lower than the mean of previous three winter peaks.

Graph 3R26: PM2.5 winter trend in Bhiwadi



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period.
Source: CSE analysis of real-time data from CPCB portal

Annexure 3R

Winter PM2.5 level at station levels among North Indian cities

S.No.	Station	State	2022-23 winter average PM2.5
1	NehruNagar	Delhi (NCR)	195
2	Jahangirpuri	Delhi (NCR)	187
3	AnandVihar	Delhi (NCR)	184
4	LodhiRoad_IITM	Delhi (NCR)	179
5	VivekVihar	Delhi (NCR)	177
6	Wazirpur	Delhi (NCR)	175
7	Mundka	Delhi (NCR)	174
8	Patparganj	Delhi (NCR)	173
9	NSIT_Dwarka	Delhi (NCR)	172
10	Shadipur	Delhi (NCR)	171
11	Rohini	Delhi (NCR)	170
12	Bawana	Delhi (NCR)	169
13	BurariCrossing	Delhi (NCR)	168
14	Narela	Delhi (NCR)	168
15	ITO	Delhi (NCR)	167
16	RKPuram	Delhi (NCR)	166
17	SoniaVihar	Delhi (NCR)	165
18	Faridabad_S16A	Haryana (NCR)	164
19	DwarkaSector8	Delhi (NCR)	164
20	PunjabiBagh	Delhi (NCR)	163
21	Alipur	Delhi (NCR)	161
22	AshokVihar	Delhi (NCR)	160
23	MDC_NationalStadium	Delhi (NCR)	159
24	Pusa_DPCC	Delhi (NCR)	156
25	OkhlaPhase2	Delhi (NCR)	155
26	Noida_S62	Uttar Pradesh (NCR)	154
27	JLN_Stadium	Delhi (NCR)	153
28	DrKS_ShootingRange	Delhi (NCR)	150
29	Ghaziabad_Vasundhara	Uttar Pradesh (NCR)	150
30	Sirifort	Delhi (NCR)	147
31	GreaterNoida_KPIII	Uttar Pradesh (NCR)	147
32	Gurugram_S51	Haryana (NCR)	146
33	Ghaziabad_Loni	Uttar Pradesh (NCR)	144
34	NorthCampus_DU	Delhi (NCR)	144
35	Faridabad_S11	Haryana (NCR)	144
36	SriAurobindoMarg	Delhi (NCR)	139
37	CRRI_MathuraRoad	Delhi (NCR)	137
38	Noida_S116	Uttar Pradesh (NCR)	136
39	Dharuhera	Haryana (NCR)	134
40	Meerut_Jaibhimnagar	Uttar Pradesh (NCR)	132
41	Baghpat_SPIC	Uttar Pradesh (NCR)	132
42	Gurugram_TeriGram	Haryana (NCR)	131

S.No.	Station	State	2022-23 winter average PM2.5
43	MandirMarg	Delhi (NCR)	131
44	Gurugram_GwalPahari	Haryana (NCR)	127
45	IGIAirportT3	Delhi (NCR)	124
46	Gurugram_VikasSadan	Haryana (NCR)	123
47	Meerut_Ganganagar	Uttar Pradesh (NCR)	123
48	GreaterNoida_KPV	Uttar Pradesh (NCR)	121
49	Pusa_IMD	Delhi (NCR)	121
50	Najafgarh	Delhi (NCR)	121
51	Muzaffarnagar	Uttar Pradesh (NCR)	120
52	Faridabad_NewIndustrialTown	Haryana (NCR)	114
53	Noida_S1	Uttar Pradesh (NCR)	114
54	Meerut_Pallavpuram	Uttar Pradesh (NCR)	113
55	Lucknow_Lalbagh	Uttar Pradesh	113
56	IHBAS	Delhi (NCR)	112
57	AyaNagar	Delhi (NCR)	111
58	Lucknow_Talkatora	Uttar Pradesh	111
59	Chandigarh_S53	Chandigarh	110
60	Faridabad_S30	Haryana (NCR)	109
61	Ghaziabad_SanjayNagar	Uttar Pradesh (NCR)	109
62	DTU	Delhi (NCR)	108
63	LodhiRoad	Delhi (NCR)	108
64	Manesar	Haryana (NCR)	107
65	Ghaziabad_Indirapuram	Uttar Pradesh (NCR)	104
66	Jind	Haryana (NCR)	102
67	ChandniChowk_IITM	Delhi (NCR)	102
68	Baddi_HIMUDA	Himachal Pradesh	100
69	Bahadurgarh	Haryana (NCR)	98
70	Charkhi_Dadri	Haryana (NCR)	96
71	Bulandshahr	Uttar Pradesh (NCR)	96
72	Hisar_UrbanEstate	Haryana	95
73	Kanpur_NehruNagar	Uttar Pradesh	94
74	Bhiwadi	Rajasthan (NCR)	93
75	Kaithal_RishiNagar	Haryana	90
76	Ludhiana_AgricultureUniversity	Punjab	90
77	Kurukshetra_S7	Haryana	88
78	MandiGobindgarh_RIMTU	Punjab	86
79	Lucknow_CentralSchool	Uttar Pradesh	86
80	Fatehabad_HudaSector	Haryana	86
81	Ballabgarh	Haryana (NCR)	85
82	Rohtak	Haryana (NCR)	84
83	Bhiwani	Haryana (NCR)	84
84	Jaipur_PoliceCommissionerate	Rajasthan	83
85	Khurja_KalindiKunj	Uttar Pradesh	82
86	YamunaNagar_GobindPura	Haryana	81
87	Amritsar_GoldenTemple	Punjab	77
88	Jodhpur	Rajasthan	76
89	Narnaul	Haryana (NCR)	76

S.No.	Station	State	2022-23 winter average PM2.5
90	Kanpur_IITK	Uttar Pradesh	75
91	Chandigarh_S22	Chandigarh	75
92	Karnal	Haryana (NCR)	74
93	Ambala_PattiMehar	Haryana	74
94	Kota_ShrinathPuram	Rajasthan	73
95	Chandigarh_S25	Chandigarh	72
96	Noida_S125	Uttar Pradesh (NCR)	70
97	Kanpur_NSI_Kalyanpur	Uttar Pradesh	70
98	Sonipat	Haryana (NCR)	70
99	Lucknow_AmbedkarUniversity	Uttar Pradesh	70
100	Sirsa_Fblock	Haryana	69
101	Hapur	Uttar Pradesh (NCR)	69
102	Jalandhar_CivilLine	Punjab	69
103	Kanpur_FTI_KidwaiNagar	Uttar Pradesh	68
104	Udaipur_AshokNagar	Rajasthan	66
105	Panchkula_S6	Haryana	63
106	Moradabad_KashiramNagar	Uttar Pradesh	63
107	Patiala_ModelTown	Punjab	62
108	Prayagraj_NagarNigam	Uttar Pradesh	62
109	Moradabad_TransportNagar	Uttar Pradesh	62
110	Moradabad_EcoHerbalPark	Uttar Pradesh	62
111	Rupnagar_Ratanpura	Punjab	61
112	Lucknow_GomtiNagar	Uttar Pradesh	61
113	Moradabad_BuddhiVihar	Uttar Pradesh	61
114	Jaipur_AdarshNagar	Rajasthan	60
115	Bareilly_CivilLines	Uttar Pradesh	60
116	Moradabad_Employment_Office	Uttar Pradesh	60
117	Khanna_KalalMajra	Punjab	60
118	Moradabad_JigarColony	Uttar Pradesh	58
119	Prayagraj_Jhunsi	Uttar Pradesh	58
120	Bareilly_RajendraNagar	Uttar Pradesh	58
121	Lucknow_Kukrail	Uttar Pradesh	58
122	Prayagraj_MNNIT	Uttar Pradesh	57
123	Gorakhpur_MMMUT	Uttar Pradesh	57
124	Agra_SanjayPalace	Uttar Pradesh	57
125	Ajmer_CivilLines	Rajasthan	56
126	Bhatinda_HardevNagar	Punjab	56
127	Jaipur_ShastriNagar	Rajasthan	55
128	Pali_IndiraColony	Rajasthan	55
129	Firozabad_VibhabNagar	Uttar Pradesh	54
130	Jhansi_ShivajiNagar	Uttar Pradesh	54
131	Alwar	Rajasthan (NCR)	52
132	Agra_S3B_AvasVikasColony	Uttar Pradesh	52
133	Varanasi_Maldahiya	Uttar Pradesh	52
134	Agra_Rohta	Uttar Pradesh	49
135	Firozabad_NaglaBhau	Uttar Pradesh	48
136	Agra_ShahjahanGarden	Uttar Pradesh	46

S.No.	Station	State	2022-23 winter average PM2.5
137	Varanasi_ArdhaliBazar	Uttar Pradesh	45
138	Srinagar_Rajbagh	Jammu & Kashmir	42
139	Agra_Shastripuram	Uttar Pradesh	42
140	Varanasi_Bhelupur	Uttar Pradesh	41
141	Vrindavan_OmexEternity	Uttar Pradesh	41
142	Varanasi_IESD_BHU	Uttar Pradesh	40
143	Panipat	Haryana (NCR)	37
144	Agra_Manoharpur	Uttar Pradesh	37
145	Palwal	Haryana (NCR)	36
146	Mandikhera	Haryana (NCR)	24

Note: October- February average is based on the mean of daily averages. All values are in μg/m^3. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB real-time data

Report 4

West Indian winter pollution: A growing concern

Towards the end of winter season, the Urban Lab at the Centre for Science and Environment (CSE) has conducted an extensive analysis of the air quality trends in West India, with a specific focus on the states of Maharashtra and Gujarat. The objective has been to understand behaviour of the winter pollution in this region this October, 2022 to February, 2023. In these states, winter pollution typically sets in during late November and early December when the cooler and calmer conditions trap locally generated high levels of 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 part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on air quality.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019, 2020, 2021, 2022 and 2023. This analysis is based on the real time data available from the current working air quality monitoring stations in West India. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis.

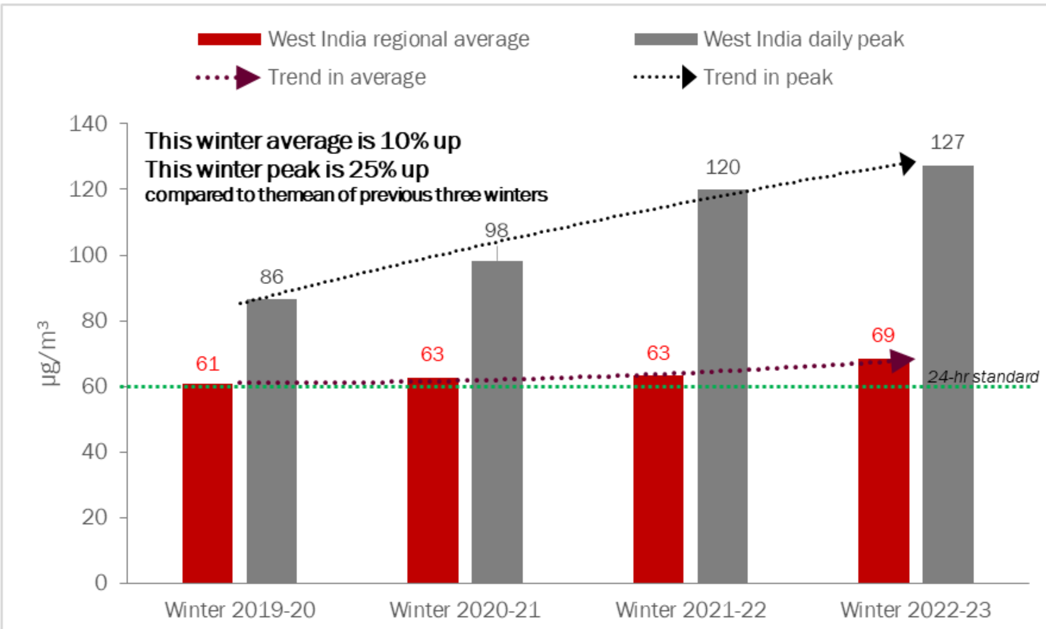
This analysis covers 58 continuous ambient air quality monitoring stations (CAAQMS) spread across 17 cities in two states: Gujarat -- nine stations in Ahmedabad, three stations in Gandhinagar, and one station each in Ankleshwar, Vapi, Vatva, Nandesari, and Surat; Maharashtra -- 21 stations in Mumbai, four stations in Navi Mumbai, eight stations in Pune, two stations in Chandrapur, and one each in Aurangabad, Kalyan, Nagpur, Nashik, Solapur, and Thane. The data is indicative of the current status of air quality and seasonal variation in particulate pollution in medium and smaller cities. Even though there are multiple real time monitors in a few cities of these states, many could not be considered for long term analysis due to data gaps and lack of quality data. Moreover, in several cases the real time monitors have been set up recently and therefore long term data is not available.

The analysis shows that the regional pollution level in West India has been rising both as seasonal average and peak. This winter has been the most polluted in the last four years. In absolute terms Gujarat has a higher pollution level but it is rising faster in Maharashtra. Most polluted locations in the region are located in Mumbai and Navi Mumbai. Vapi and Surat are the most polluted locations in Gujarat. Nagpur registered the most increase in pollution with a 105 per cent rise compared to the previous winter.

Key findings: Regional

<u>This winter was the most polluted in the last four years in West India</u>: The average PM2.5 level across cities of West India stood at 69 µg/m³ this winter (See *Graph 4R1: Trend in West India's winter PM2.5 average*). It is 10 per cent higher than the mean of the previous three winters. Daily peak for the region this winter happened on 24 October 2022 (day after Diwali) and it was 127 µg/m³. It was 25 per cent higher than the mean of the previous three winter peaks.

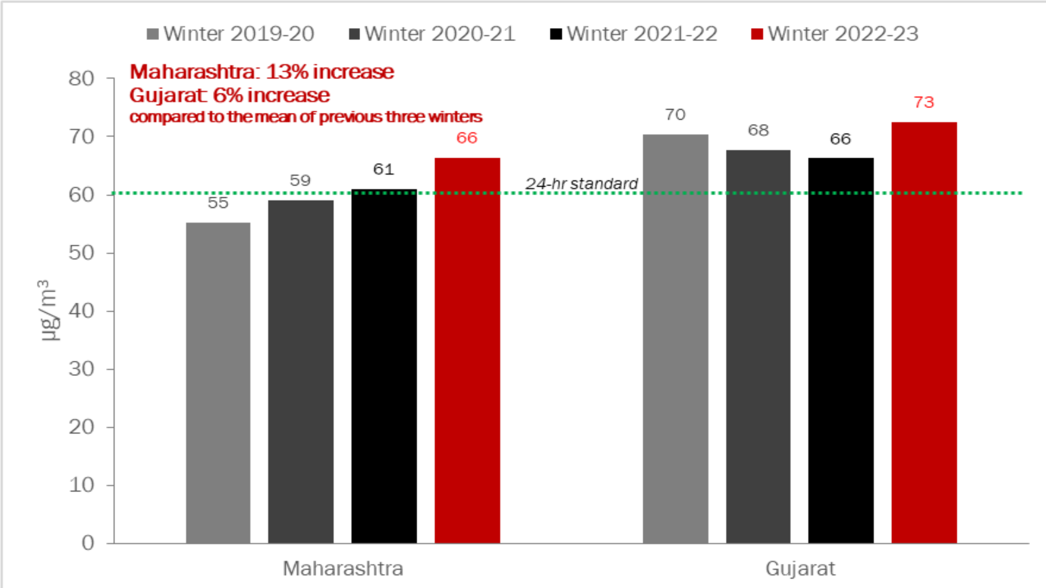
Graph 4R1: Trend in West India's winter PM2.5 average



Note: 15 cities that constitute West India regional average are Ahmedabad, Ankleshwar, Gandhinagar, Nandesari, Vapi, Vatva, Mumbai, Navi Mumbai, Pune, Aurangabad, Chandapur, Kalyan, Nasik, Nagpur and Solapur. Winter is defined as 1 October-28 February. Winter average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data.

<u>It was the most polluted winter for both states of West India in the last four years</u>: Winter pollution level in Maharashtra rose by 13 per cent compared to the mean of the previous three winters. Winter pollution has been rising in Maharashtra on a yearly basis and stood at 66 µg/m³ this winter. On an absolute level Gujarat was more polluted of the two states with a winter average of 73 µg/m³. Gujarat registered an increase of 6 per cent compared to the mean of previous three winters (See *Graph 4R2: Trend in winter PM2.5 levels for states of West India*). Winter pollution was on a decline in Gujarat since 2019 but it spiked up this winter.

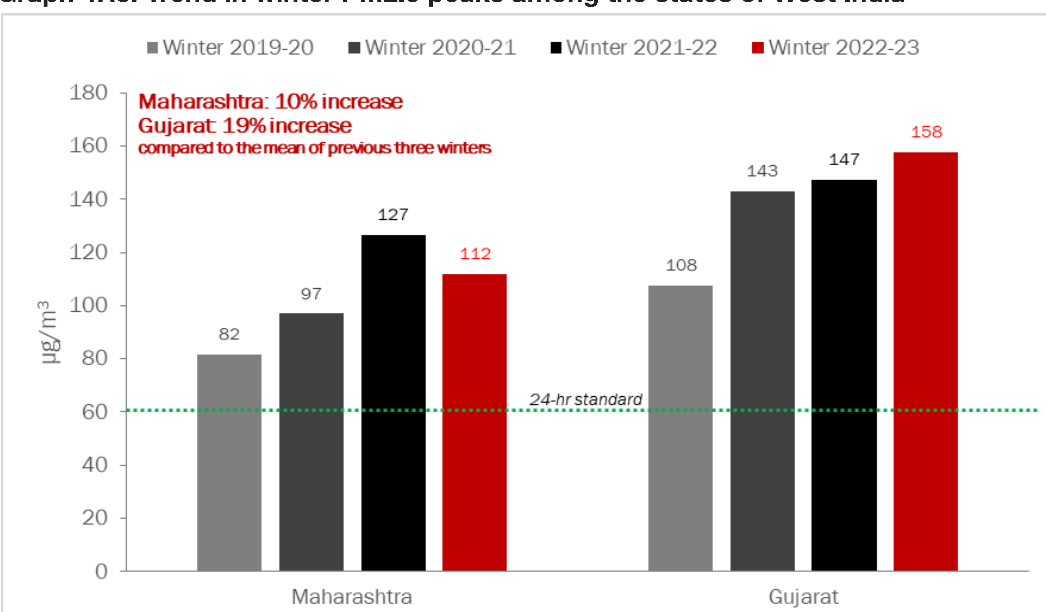
Graph 4R2: Trend in winter PM2.5 levels for states of West India



Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

<u>Peak pollution is growing faster in Gujarat but is a problem in Maharashtra as well</u>: Gujarat had its peak daily PM2.5 of 158 µg/m^3 on 24 October 2022. This was the highest regional peak in the last four years and was 19 per cent higher than the mean of the previous three winter peaks. Maharashtra's peak daily PM2.5 happened much later on 2 December 2022. Maharashtra's daily PM2.5 peak stood at 112 µg/m^3, which is marginally lower than the 2021-22 winter peak but 10 per cent higher than the mean of the previous 3 winter peaks (See *Graph 4R3: Trend in winter PM2.5 peaks among the states of West India*).

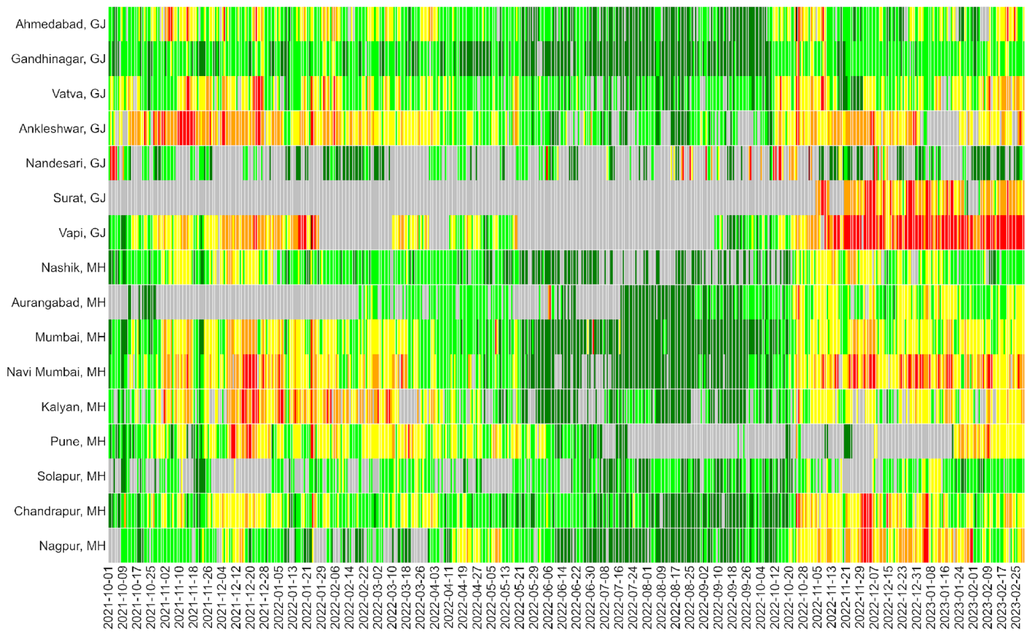
Graph 4R3: Trend in winter PM2.5 peaks among the states of West India



Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

<u>Winter air gets dirty across cities of West India in a synchronised way</u>: Worsening of air quality starts mid-October across West India in a synchronised fashion as weather starts to cool down and winds get slow (See *Graph 4R4: Air quality heat map of West Indian cities*). But the analysis is hampered by poor data quality among the stations of the region. Data for 96 days is missing from stations in Pune, while in Nandisari 68 days data is missing. There are large gaps in data from other stations as well.

Graph 4R4: Air quality heat map of West Indian cities

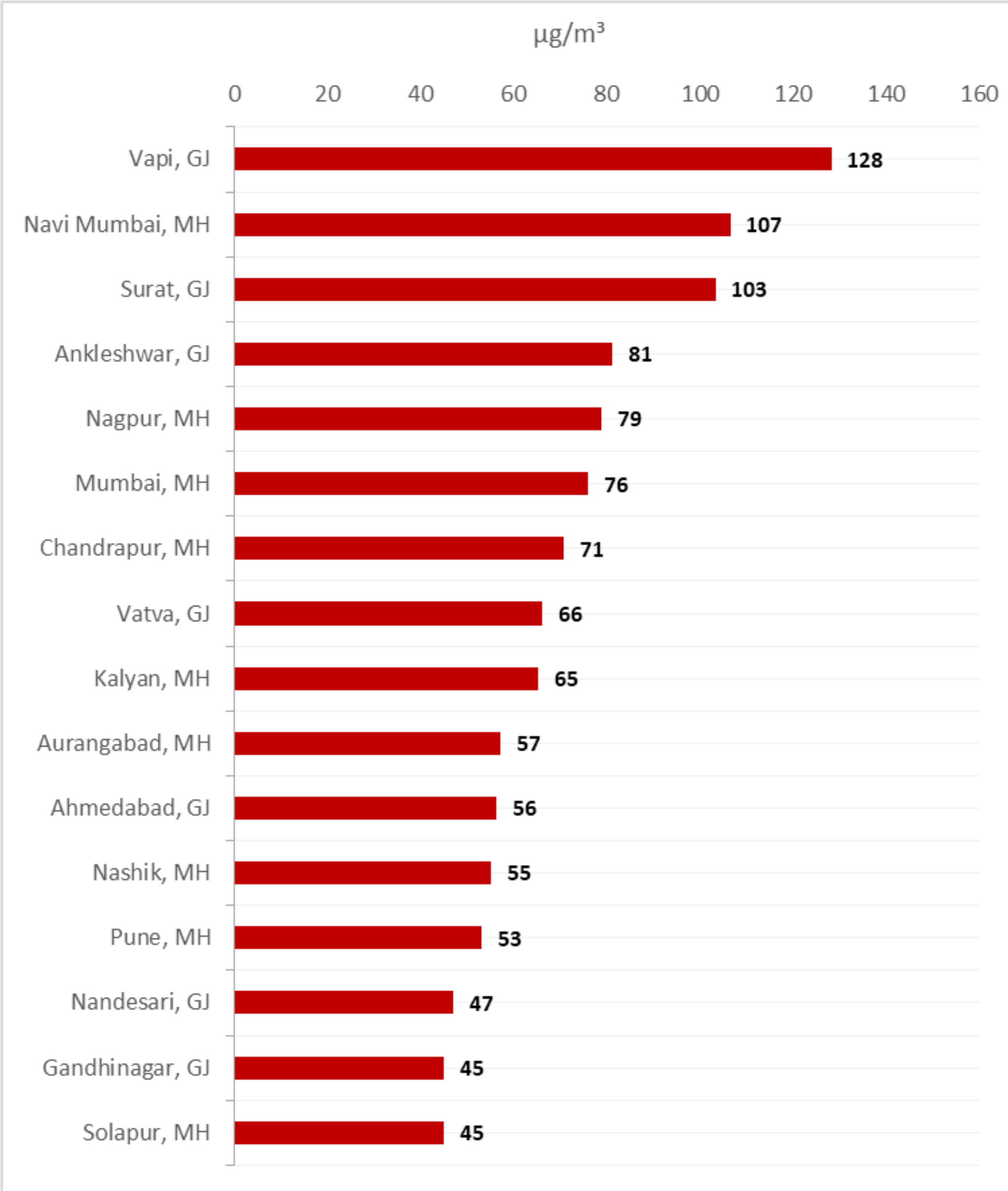


Note: Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB real-time data

<u>Vapi has the most polluted air in West India followed by Navi Mumbai</u>: Vapi was the most polluted city in West India with average PM2.5 of 128 µg/m^3. It was followed by Navi Mumbai with 107 µg/m^3, and Surat with 103 µg/m^3 (See *Graph 4R5: Winter PM2.5 level among West Indian cities).* Gandhinagar in Gujarat was the least polluted city with an average PM2.5 of 45 µg/m^3. Solapur in Maharashtra also has a seasonal average 45 µg/m^3 but due to excessive missing data (36 days of missing data) it cannot be certain if the seasonal pollution was as low. Same goes for cities of Nandesari and Pune which have high numbers of missing data.

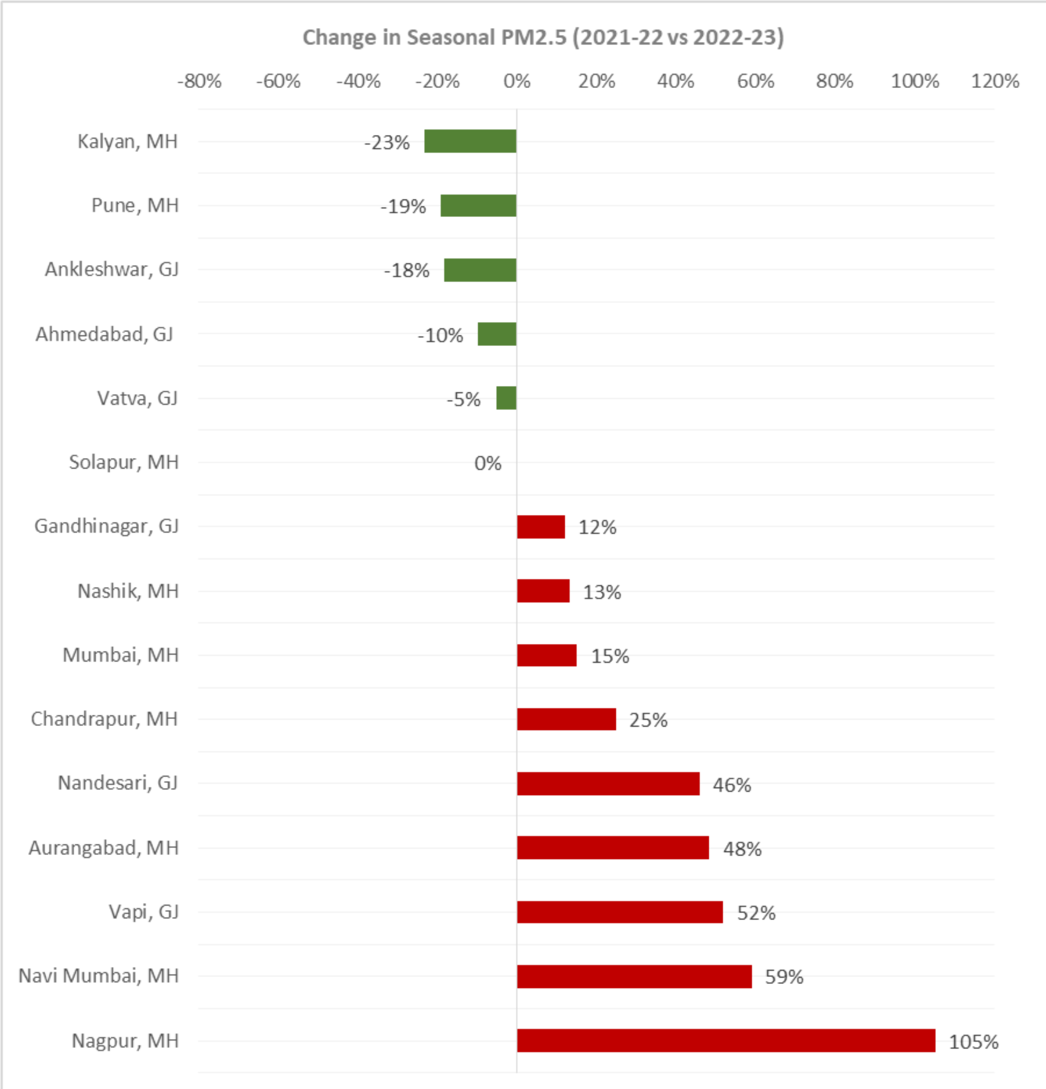
Nagpur registered the most increase in pollution this winter: Kalyan in Maharashtra has shown the most improvement in air quality this season compared to the same period previous year with 23 per cent. It is followed by Pune with 19 per cent, Ankleshwar with 18 per cent, Ahmedabad with 10 per cent and Vatva with 5 per cent lower PM2.5 compared to previous year. Solapur shows no improvement. (See *Graph 4R6: Change in winter PM2.5 levels among West Indian cities 2021-22 vs 2022-23*). Nagpur in Maharashtra was the worst performer and registered an increase of 105 per cent from last year. It was followed by Navi Mumbai and Vapi with an increase of 59 per cent and 52 per cent.

Graph 4R5: Winter PM2.5 level among West Indian cities



Note: 1 October 2022-28 February 2023 average is based on mean of daily averages. Cities with multiple stations are represented by the mean of all city stations.
Source: CSE analysis of CPCB real-time data

Graph 4R6: Change in winter PM2.5 level among West Indian cities 2021-22 vs 2022-23

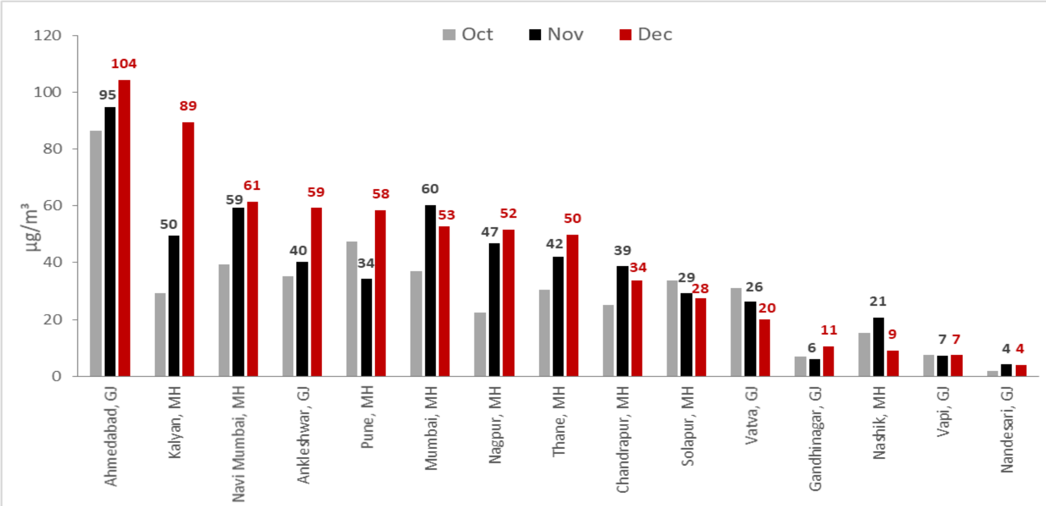


Note: 1 October-28 February 2021-22 and 2022-23 average is based on mean of daily averages. Cities with multiple stations are represented by the mean of all city stations. Cities with data in both 2021 and 2022 are compared.
Source: CSE analysis of CPCB real-time data

<u>Increasing levels of Nitrogen dioxide (NO2) during November and December</u>: There is a significant increase in the amount of NO2 in air during November and December compared to October. NO2 comes entirely from combustion sources and significantly from vehicles. Kalyan in Maharashtra has registered the greatest increase of 3 times maximum build-up of NO2 between October and December. Nagpur and Nadesari each registered 2.3 times increase in NO2.

In absolute concentration terms, Ahmedabad registered the highest NO2 average of 104 µg/m^3 (See *Graph 4R7: Trend in NO2 levels among sub-regions of West India*). It is followed by Kalyan with 89 µg/m^3 and Navi Mumbai with 61 µg/m^3. The lowest NO2 level was recorded by Nadesari with 4 µg/m^3 and Vapi with 7 µg/m^3.

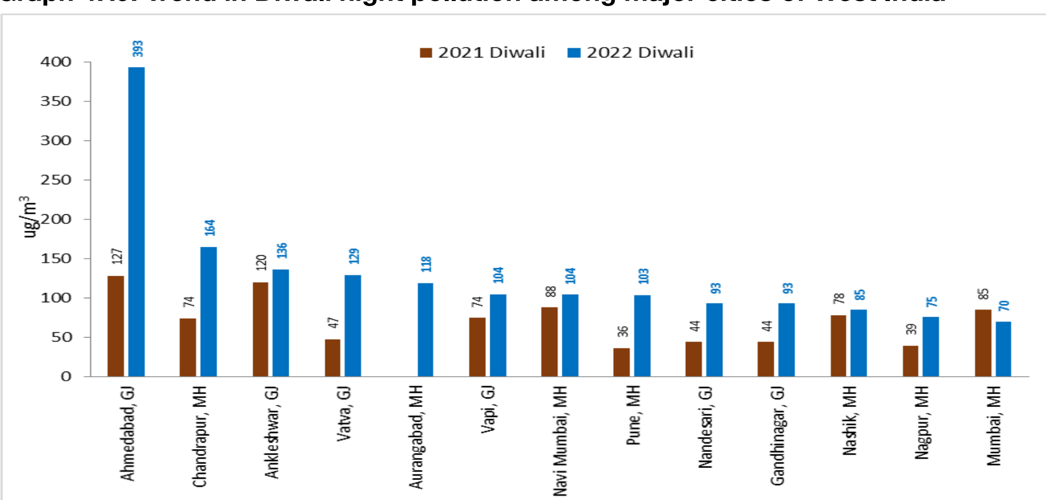
Graph 4R7: Trend in NO2 levels among sub-regions of West India



Note: NO2 values for sub-regions are based on the average of citywide values of all the cities in that region. NO2 values for cities with more than one monitoring station is based on the average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2022.
Source: CSE analysis of real-time data from CPCB portal

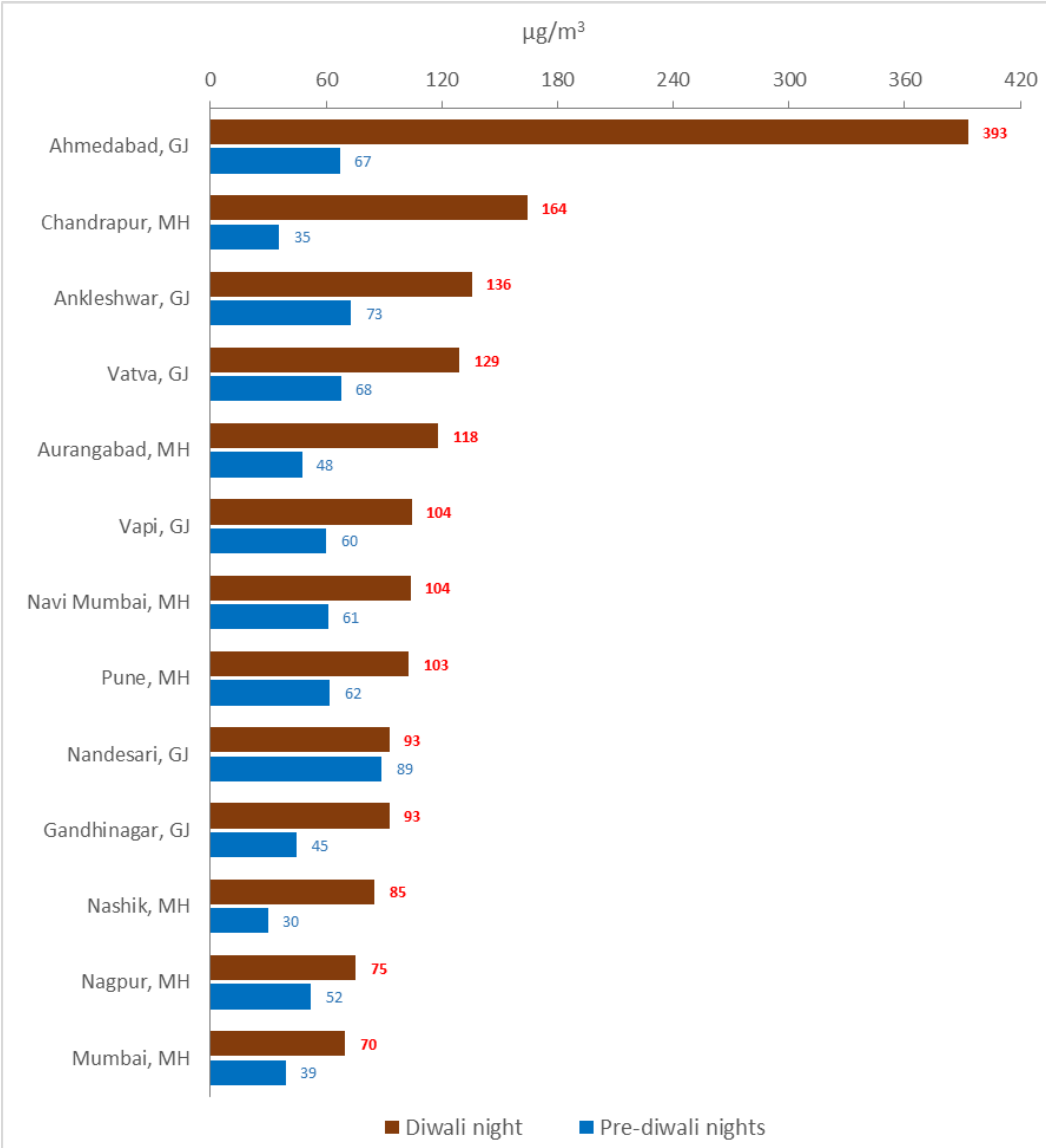
<u>Diwali pollution is highest among cities of Gujarat in the West Indian Region</u>: Pollution level on Diwali night (8pm to 8am) in cities shot up by 1 – 5.9 times the average level recorded seven nights preceding Diwali (See *Graph 4R8: Diwali night pollution among cities of West India*). Ahmedabad in Gujarat saw the greatest jump of 5.9 times higher PM2.5 level on Diwali night at 393 µg/m^3. It is followed by Chandrapur in Maharashtra with 4.6 time's higher PM2.5 concentration. The Gujarat cities dominate the list of top five most polluted cities with Chandrapur and Aurangabad of Maharashtra at second and fifth rank. Mumbai and Nagpur had the least polluted Diwali night in the region each with 70 µg/m^3 and 75 µg/m^3 followed by Nashik with 85 µg/m^3. This Diwali is more polluted compared to last year's Diwali for all major cities in the region. Ahmedabad had seen the maximum increase on Diwali night (See *Graph 4R9: Trend in Diwali night pollution among major cities of West India*).

Graph 4R9: Trend in Diwali night pollution among major cities of West India



Note: PM2.5 values for cities with more than one monitoring station is based on average of all stations that have continuous and adequate data for complete assessment period. Diwali night is considered from 8.00PM to 8.00AM on 4 November 2021 and 24 October 2022.
Source: CSE analysis of real-time data from CPCB portal.

Graph 4R8: Diwali night pollution among cities of West India



Note: PM2.5 values for cities with more than one monitoring station is based on average of all stations that have continuous and adequate data for complete assessment period. Diwali night is considered from 8.00PM October 24 to 8.00AM October 25. Pre-diwali night is an average of seven nights (8.00PM-8.00AM) preceding Diwali.
Source: CSE analysis of real-time data from CPCB portal

Most polluted locations in West India are located in the Greater Mumbai region: Navi Mumbai's Sector 19A monitoring station was the most polluted location in West India with PM2.5 average of 164 µg/m³. Vapi's monitoring station at GIDC was the second most polluted location. Mumbai's monitoring stations at Deonar, Bandra-Kurla Complex, Mazgaon, Navy Nagar, Chakala and Vile Parle West make up six of the ten most polluted locations in West India (See *Annexure 4R: Winter PM2.5 level at station levels among West Indian cities*). Surat is the only other city that features among the ten most polluted locations.

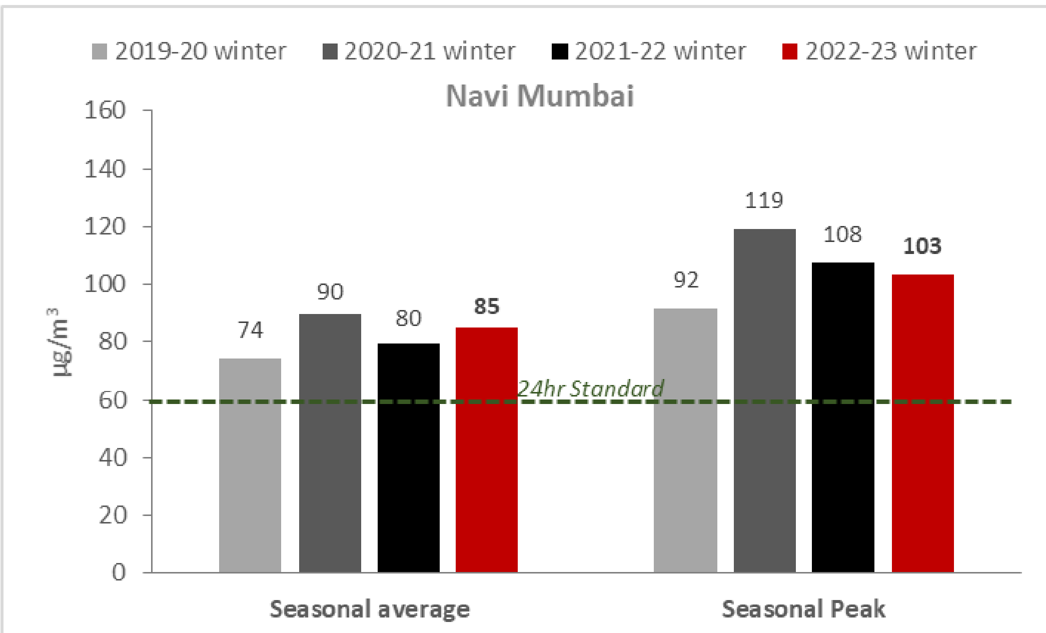
Key findings: Cities

Note: This does not include Mumbai as it has been covered in the mega-cities analysis under Report 2.

Maharashtra: Navi Mumbai

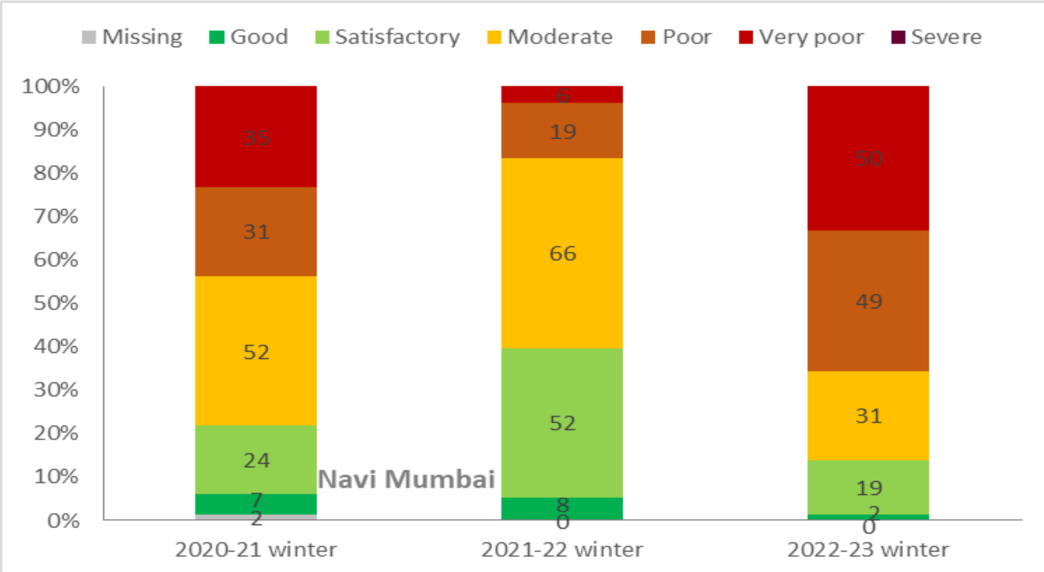
Winter pollution level in Navi Mumbai this season has been 5 per cent higher than the mean of previous three winters and is considerably higher than the standard. But there has been a 3 per cent decline in winter peak compared to the mean of peaks of the previous three winters (See *Graph 4R10: PM2.5 winter trend in Navi Mumbai*). AQI categorization shows that the city's air quality has not deteriorated to severe days in last three years but the number of days with poor and very poor air quality has increased this winter compared to last year going from 25 to 99 bad days (See *Graph 4R11: PM2.5 AQI trend in Navi Mumbai*).

Graph 4R10: PM2.5 winter trend in Navi Mumbai



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R11: PM2.5 AQI trend in Navi Mumbai

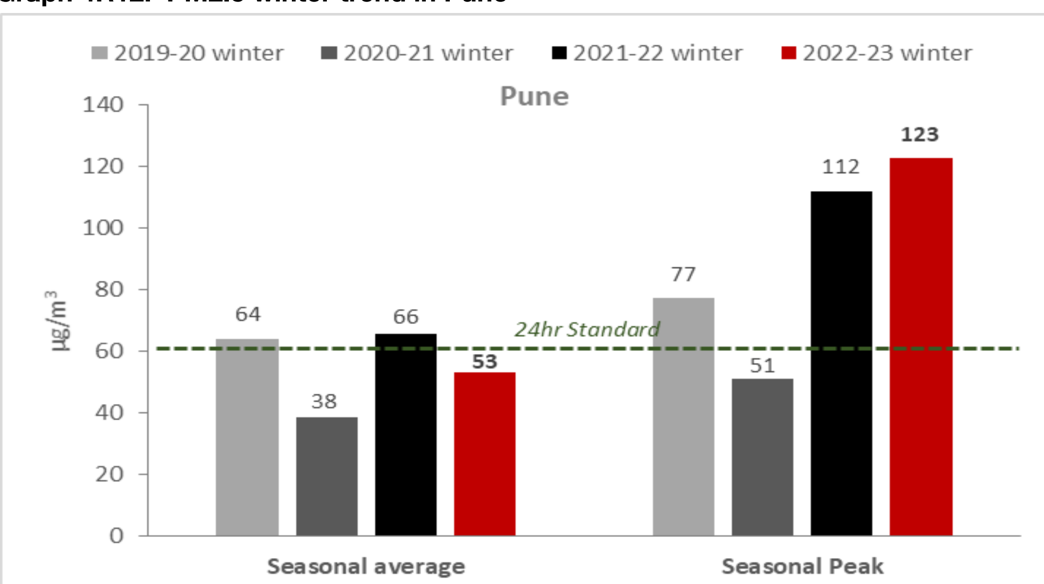


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Maharashtra: Pune

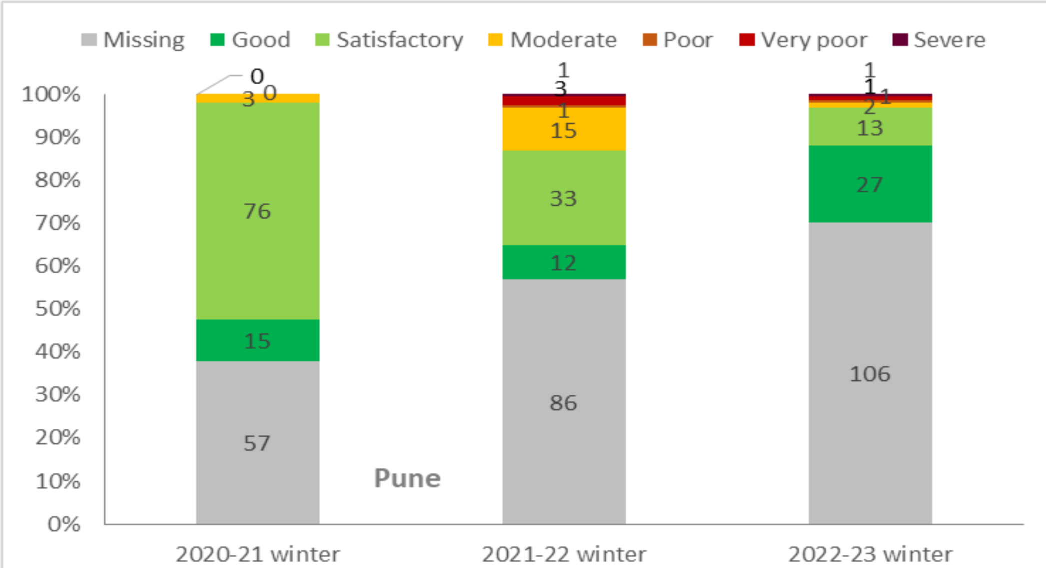
Winter pollution level in Pune this season has been 5 per cent lower than the mean of previous three winters. However, there has been a drastic increase in winter peak with 53 per cent compared to the mean of peaks of previous three winters, highest in all past four winters. (See *Graph 4R12: PM2.5 winter trend in Pune*). AQI categorization shows that the city's air quality has deteriorated to 1 severe day this winter. Due to the large number of missing data, accurate air quality days cannot be computed. Otherwise there would be more bad AQI days in the city (See *Graph 4R13: PM2.5 AQI trend in Pune*).

Graph 4R12: PM2.5 winter trend in Pune



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R13: PM2.5 AQI trend in Pune

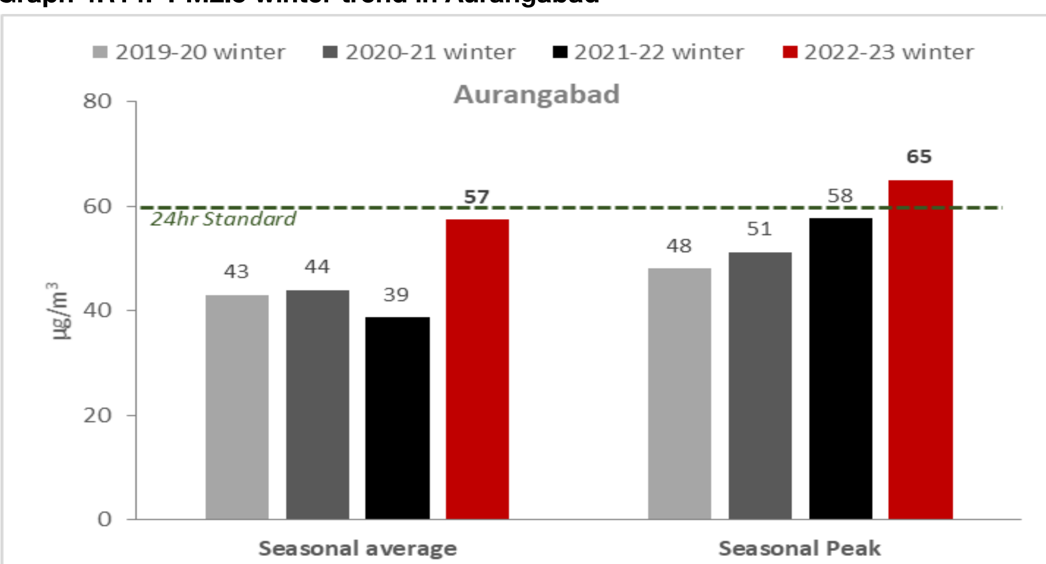


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Maharashtra: Aurangabad

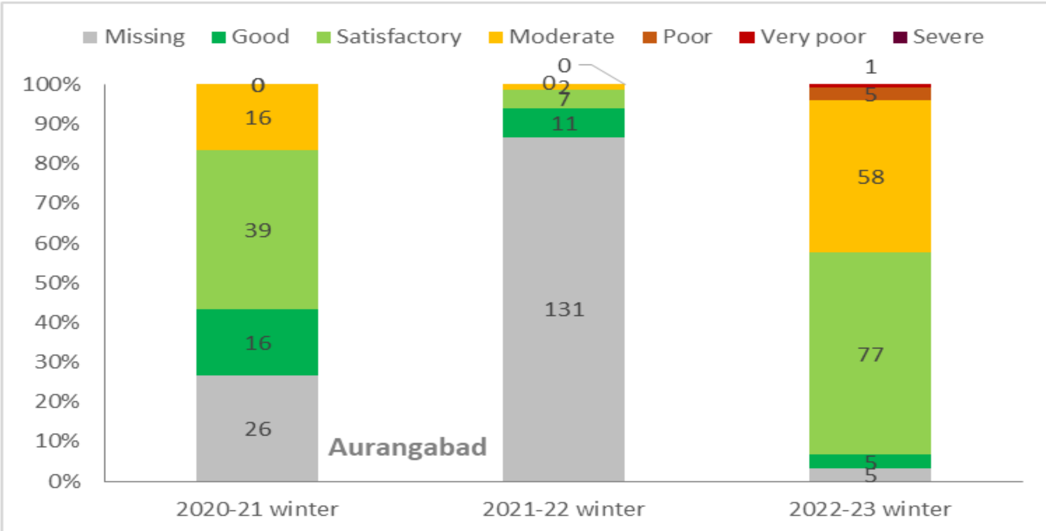
Winter pollution level in Aurangabad this season has been 37 per cent higher than the mean of previous three winters and with a seasonal average of 57 µg/m^3 the city's air quality is considerably higher than the last three winters. Similarly, there has been a 24 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 4R14: PM2.5 winter trend in Aurangabad*). AQI categorization shows that the city's air quality has not deteriorated to severe air quality but had 6 days of very poor and poor air quality, an increase compared to previous two winters (See *Graph 4R15: PM2.5 AQI trend in Aurangabad*). The number of good days has also decreased this winter.

Graph 4R14: PM2.5 winter trend in Aurangabad



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R15: PM2.5 AQI trend in Aurangabad

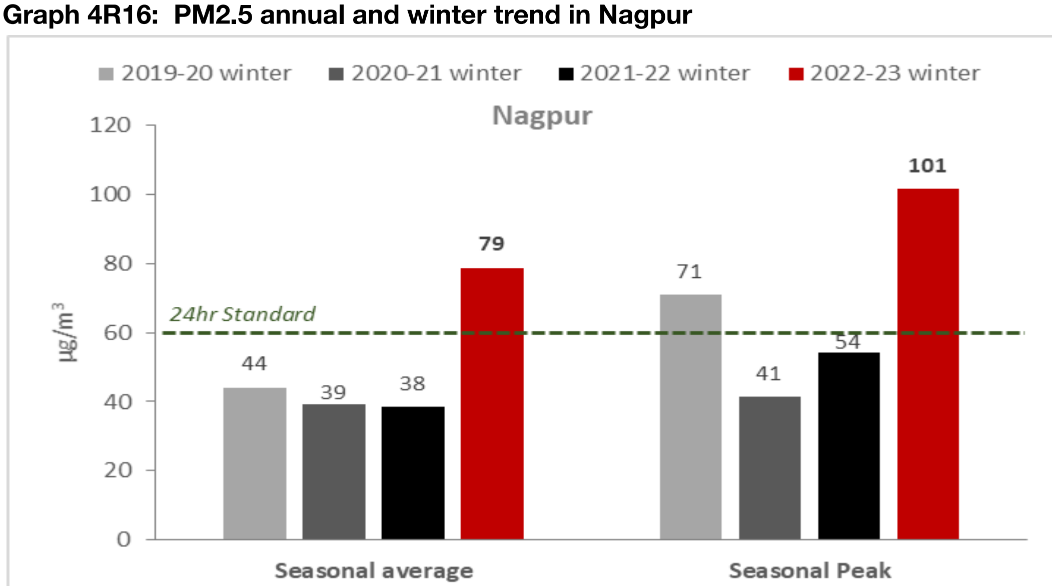


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Maharashtra: Nagpur

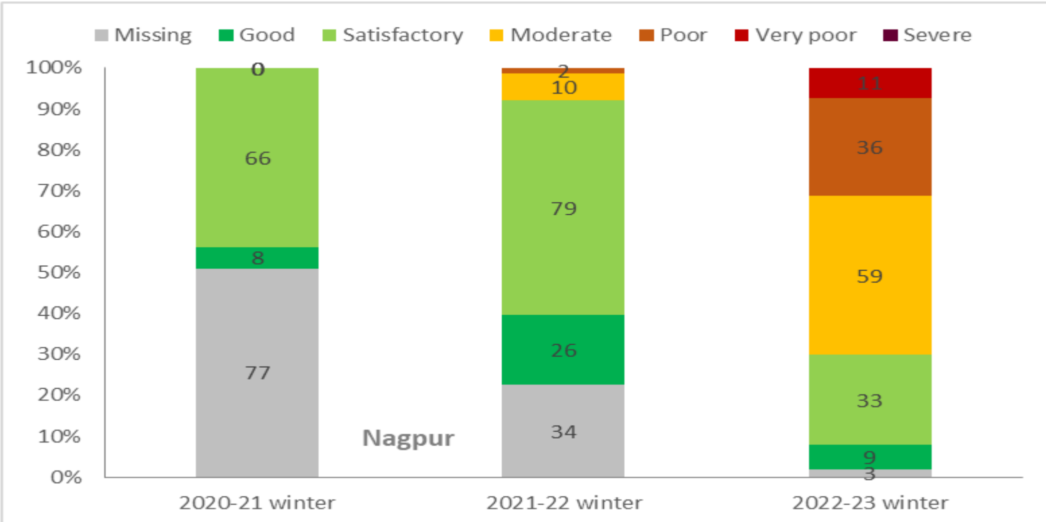
Winter pollution level in Nagpur this season has been 94 per cent higher than the mean of previous three winters and with a seasonal average of 79 µg/m^3 the city's air quality is considerably higher than the standard. Similarly, there has been an 83 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 4R16: PM2.5 winter trend in Nagpur*). AQI categorization shows that the city's air quality has deteriorated considerably this winter with 47 days of very poor and poor air quality, a considerable increase compared to previous two winters (See *Graph 4R17: PM2.5 AQI trend in Nagpur*). There were only 2 "poor" days in the 2021-22 winter and zero "very poor" and "poor" days in the 2020-21 winter.

Graph 4R16: PM2.5 annual and winter trend in Nagpur



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R17: PM2.5 AQI trend in Nagpur

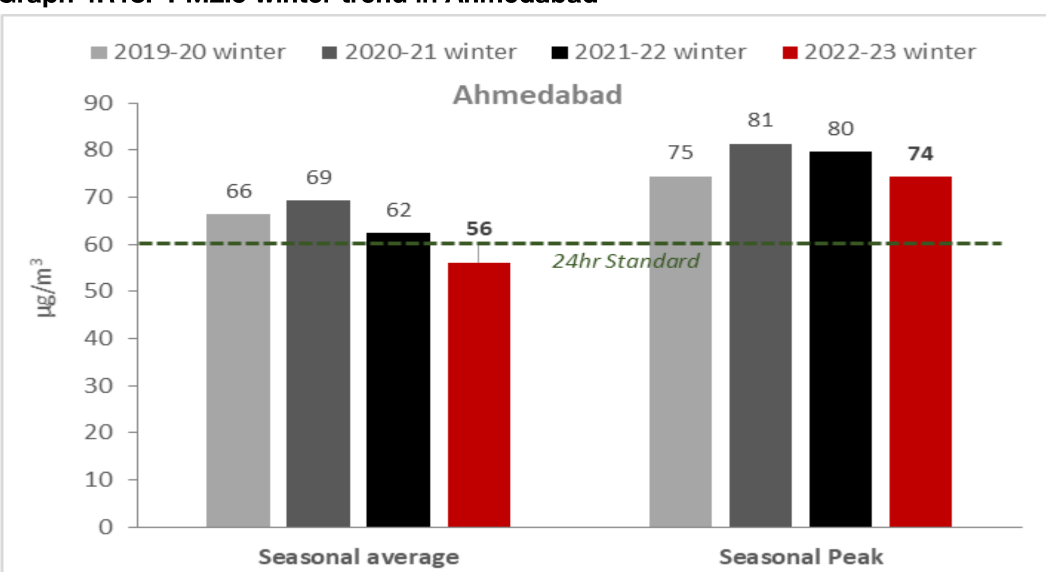


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Gujarat: Ahmedabad

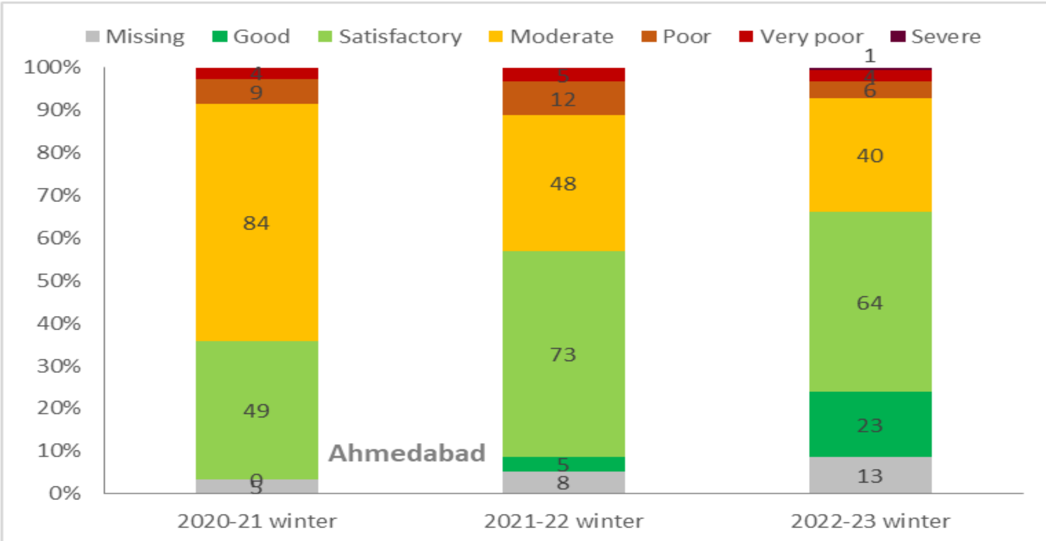
Winter pollution level in Ahmedabad this season has been 15 per cent lower than the mean of previous three winters and with seasonal average of 56 µg/m^3, considerably lower than the last three winters average. Similarly, there has been a 5 per cent decrease in winter peak compared to the mean of peaks of the previous three winters (See *Graph 4R18: PM2.5 winter trend in Ahmedabad*). AQI categorization shows that the city's air quality has deteriorated this winter with 1 day of severe air quality in the last three years. The city had 10 days of very poor and poor air quality, a considerable decrease compared to previous two winters (See *Graph 4R19: PM2.5 AQI trend in Ahmedabad*). There were 17 bad days in the 2021-22 winter and 13 bad days in the 2020-21 winter.

Graph 4R18: PM2.5 winter trend in Ahmedabad



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R19: PM2.5 AQI trend in Ahmedabad

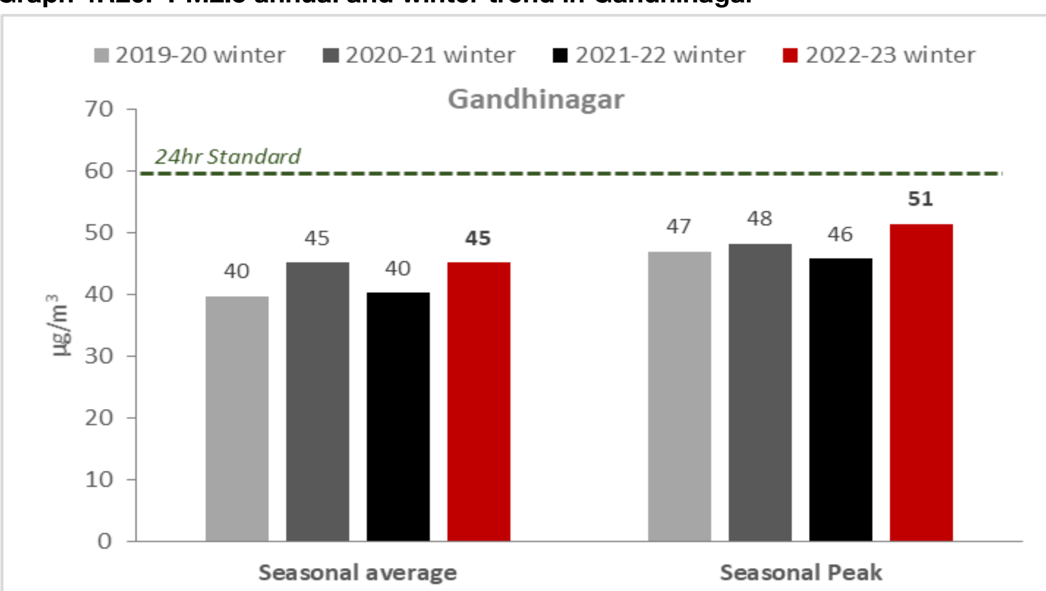


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Gujarat: Gandhinagar

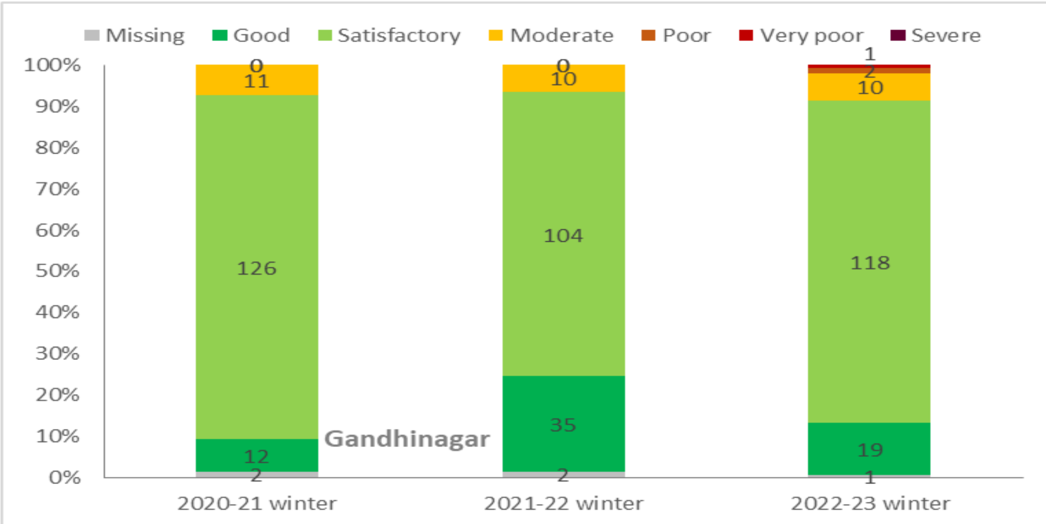
Winter pollution level in Gandhinagar this season has been 8 per cent higher than the mean of previous three winters and with seasonal average of 45 µg/m^3 the city's air quality is almost consistent in the city from the last three winters. Similarly, there has been a 10 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 4R20: PM2.5 winter trend in Gandhinagar*). AQI categorization shows that the city's air quality has deteriorated with 3 days of very poor and poor air quality, which was zero in previous two winters (See *Graph 4R21: PM2.5 AQI trend in Gandhinagar*). The number of good air days decreased this winter compared to last winter, going from 35 to 19 good days.

Graph 4R20: PM2.5 annual and winter trend in Gandhinagar



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R21: PM2.5 AQI trend in Gandhinagar

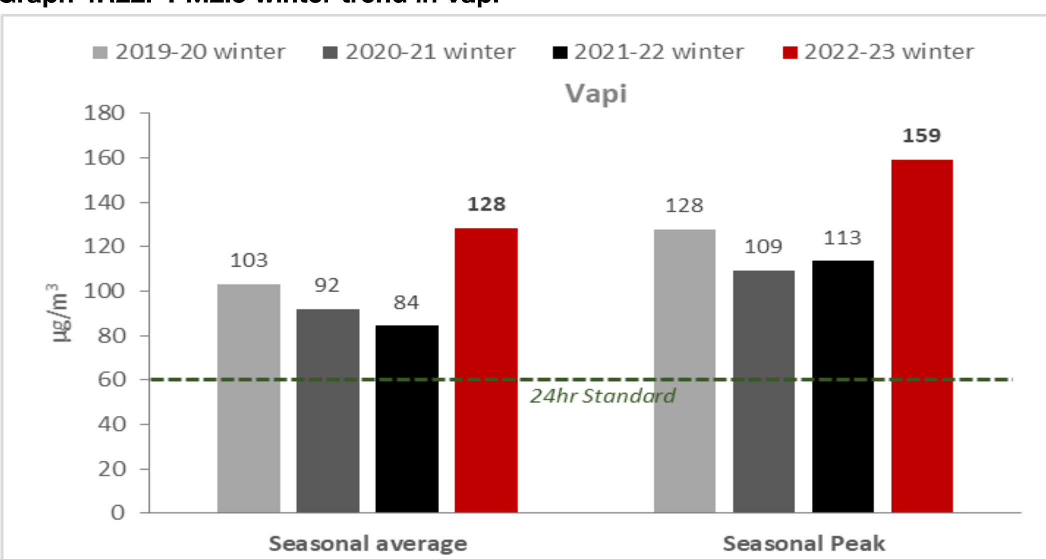


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Gujarat: Vapi

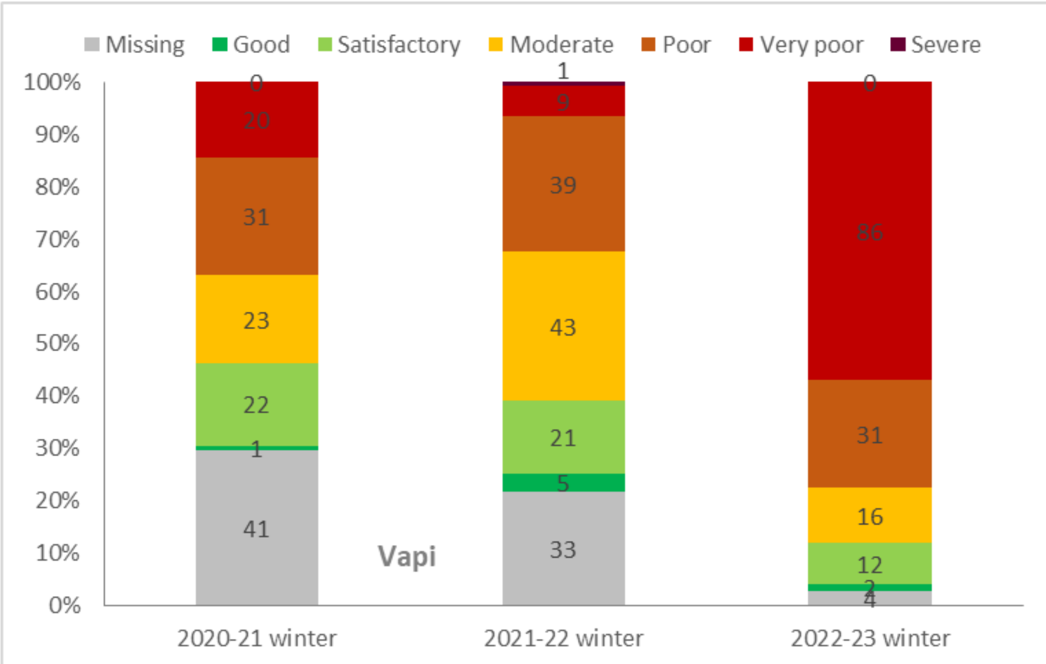
Winter pollution level in Vapi this season has been 38 per cent higher than the mean of previous three winters and with seasonal average of 128 µg/m^3, higher than the last three winters average. Similarly, there has been a 36 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 4R22: PM2.5 winter trend in Vapi*). AQI categorization shows that the city's air quality has not deteriorated this winter with severe air quality. However the city had a tremendous increase in "very poor" and "poor" air quality within 117 days, compared to previous two winters (See *Graph 4R23: PM2.5 AQI trend in Vapi*). There were 48 bad days in the 2021-22 winter and 51 bad days in the 2020-21 winter.

Graph 4R22: PM2.5 winter trend in Vapi



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 4R23: PM2.5 AQI trend in Vapi



Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Annexure 4R

Winter PM2.5 level at station levels among West Indian cities

	Station	State	2021-22 winter	2022-23 winter
1	Navi Mumbai_S 19A Nerul (IITM)	Maharashtra	53	164
2	Vapi_Ph1_GIDC	Gujarat	84	128
3	Mumbai_Deonar (IITM)	Maharashtra	71	123
4	Mumbai_BKC (IITM)	Maharashtra	74	120
5	NaviMumbai_Nerul	Maharashtra	82	116
6	Mumbai_Mazgaon (IITM)	Maharashtra	119	109
7	Mumbai_NavyNagar (IITM)	Maharashtra	89	104
8	Surat_ScienceCenter	Gujarat		103
9	Mumbai_Chakala (IITM)	Maharashtra	72	98
10	Mumbai_VileParleWest	Maharashtra	76	89
11	Mumbai_MulundW	Maharashtra	68	83
12	Mumbai_Sion	Maharashtra	57	82
13	Ankleshwar_GIDC	Gujarat	99	81
14	Nagpur	Maharashtra	38	79
15	Mumbai_Khindipada_IITM	Maharashtra	48	77
16	Chandrapur	Maharashtra	51	73
17	Mumbai_Powai	Maharashtra	68	71
18	Mumbai_KandivaliEast	Maharashtra	64	69
19	Vatva_Ph4_GIDC	Gujarat	70	66
20	Kalyan_Khadakpada	Maharashtra	85	65
21	Mumbai_Colaba	Maharashtra	64	63
22	Mumbai_BorivaliEast	Maharashtra	62	60
23	Mumbai_Worli	Maharashtra	71	60
24	Mumbai_SiddharthNagar (IITM)	Maharashtra	52	58
25	Aurangabad	Maharashtra	39	57
26	Mumbai_CSIA_T2	Maharashtra	52	57
27	Mumbai_VasaiWest	Maharashtra	59	57
28	Ahmedabad_Maninagar	Gujarat	62	56
29	Nashik	Maharashtra	49	55
30	Chandrapur_Khutala	Maharashtra	62	55
31	NaviMumbai_Mahape	Maharashtra	77	54
32	Pune_KarveRoad	Maharashtra	66	53
33	Mumbai_MaladW (IITM)	Maharashtra	43	48
34	Nandesari_GIDC	Gujarat	32	47
35	Gandhinagar_S10	Gujarat	40	45
36	Solapur	Maharashtra	45	45
37	Mumbai_Kurla	Maharashtra	79	39

Note: October- February average is based on the mean of daily averages. All values are in µg/m^3. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB real-time data

Report 5

East Indian winter pollution: Overview of the air quality crisis

As the winter comes to an end, the Urban Lab at Centre for Science and Environment (CSE) has analysed air quality trends so far in East India. The focus is on West Bengal, Bihar, Odisha and Jharkhand. The objective has been to understand behaviour of the winter pollution in this region this October, 2022 to February, 2023. Bihar, West Bengal and Odisha are affected mostly during this time when winter inversion, cool and calm conditions trap local pollution that is already high. This also helps to locate the winter season within the longer term context of seasonal variation and annual trends in particulate pollution. This is part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on air quality.

Analysis shows that the winter air quality in East India as a region has started to dip after marginal improvement noted in the previous two winters. Pollution levels in Kolkata and Patna continue to be high but the situation is much worse among smaller towns especially in Bihar. Begusarai, Bettiah and Siwan have the worst winter air in the region with their seasonal average exceeding 200 µg/m^3. Nitrogen dioxide (NO2) pollution is also high in the cities and towns of the region with Arrah recording a staggering 113 µg/m^3 monthly average for November.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019, 2020, 2021, 2022 and 2023. This analysis is based on the real time data available from the current working air quality monitoring stations in East India. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis.

This analysis covers 50 continuous ambient air quality monitoring stations (CAAQMS) spread across 32 cities in three states: West Bengal -- seven stations in Kolkata, three stations in Howrah, and one station each in Asansol, Siliguri, Durgapur, Haldia; Bihar - six stations in Patna, three stations in Gaya, three stations in Muzaffarpur, two stations in Bhagalpur, and one each in Hajipur, Bettiah, Bihar Sharif, Darbhanga, Motihari, Araria, Arrah, Chhapra, Katihar, Kishanganj, Manguraha, Munger, Purnia, Rajgir, Saharsa, Sasaram, Siwan, Aurangabad, Begusarai, and Samastipur; Odisha -- one real time station each in Talcher and Brajrajnagar.

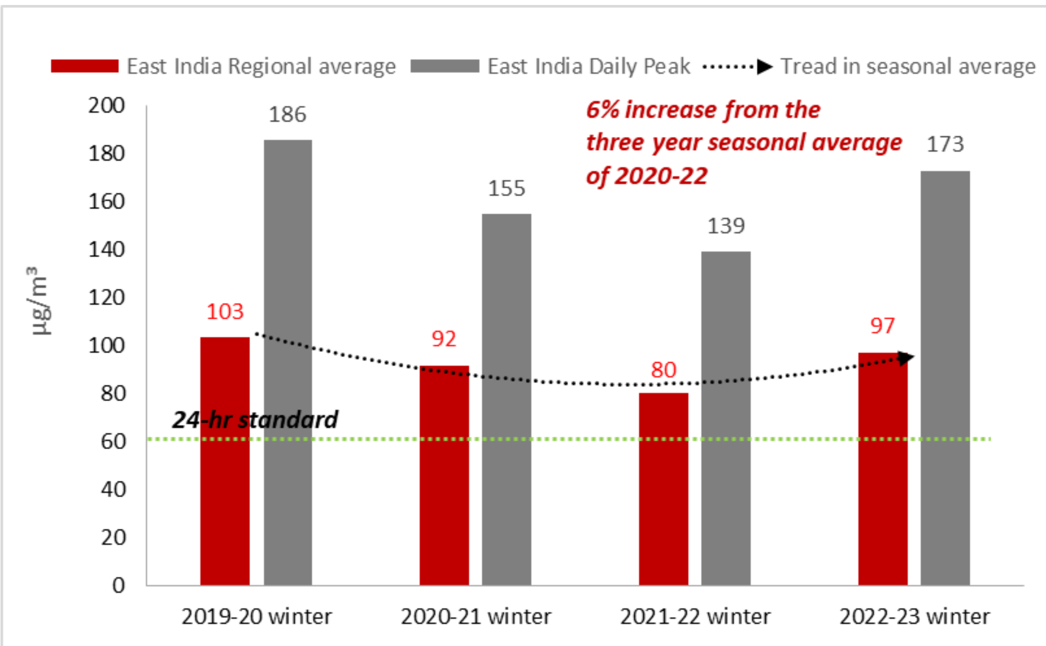
Even though there are more real time monitors in a few other cities of these states, and also in Jharkhand, those could not be considered due to data gaps and lack of quality data. Moreover, in several cases the real time monitors have been set up recently and therefore long term data is not available. In West Bengal, real time monitors in Durgapur and Haldia became operational only near the end of 2020 which limits the possibility of doing long term trend analysis for these cities. Therefore data is indicative of the current status of air quality and seasonal variation in particulate pollution in medium and smaller cities. Many new stations have been added in November 2022 in Odisha: one station each in Baripada, Bileipada, Keonjhar, Nayagarh, Rairangpur, Rorkela, Suakati and Tensa.

Key findings: Regional

<u>This winter was the most polluted since 2019-20 winter</u>: The average PM2.5 level across 9 cities of East India with functional CAAQMS stations since 2019 stood at 97 µg/m³ this winter for time period of 1 October to 28 February (See *Graph 5R1: Trend in East India's winter PM2.5 levels in 1 Oct-28 Feb*). PM2.5 level this 1 October-28 February has been 6 per cent higher compared to average of previous three winters.

Daily peak this season happened on 1 January and the daily regional average stood at 173 µg/m³. Peak was 24 per cent higher compared to the peak of the 2021-22 winter and 8 per cent higher compared to the mean peak of previous three winters.

Graph 5R1: Trend in East India's winter PM2.5 levels

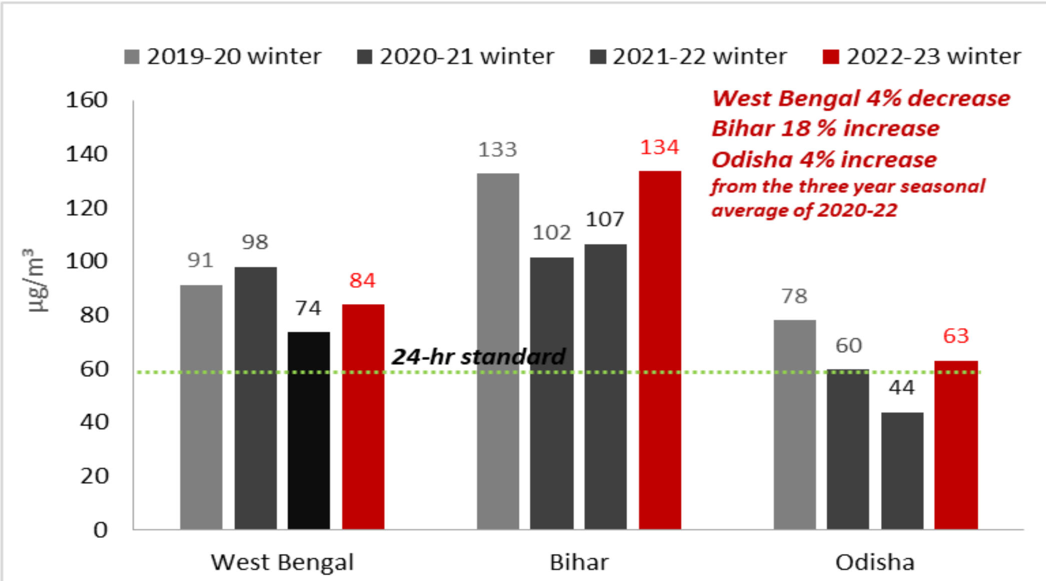


Note: 9 cities that constitute East India regional average are Kolkata, Howrah, Asansol, Siliguri, Patna, Gaya, Muzaffarpur, Talcher and Brajrajnagar. PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of CPCB real-time data.

<u>All states of East India had experienced a spike in pollution this winter</u>: West Bengal's winter average PM2.5 this year is 14 per cent higher than the last winter. Bihar registered 26 per cent and Odisha 44 per cent higher winter average compared to the last winter (See *Graph 5R2: Trend in winter PM2.5 levels among states of East India*). In the long term, the seasonal air quality in West Bengal this winter is 4 per cent better than the mean of previous three winters, while Bihar registered 18 per cent increase and Odisha 4 per cent increase from the mean of previous three winters. The monitoring station Jharkhand has no PM2.5 data for the last 2 years, so it is not included in this analysis.

In absolute concentration terms, Bihar with average PM2.5 of 134 µg/m³ was the most polluted state of East India followed by West Bengal with average PM2.5 of 84 µg/m³ and Odisha registered seasonal average of 63 µg/m³.

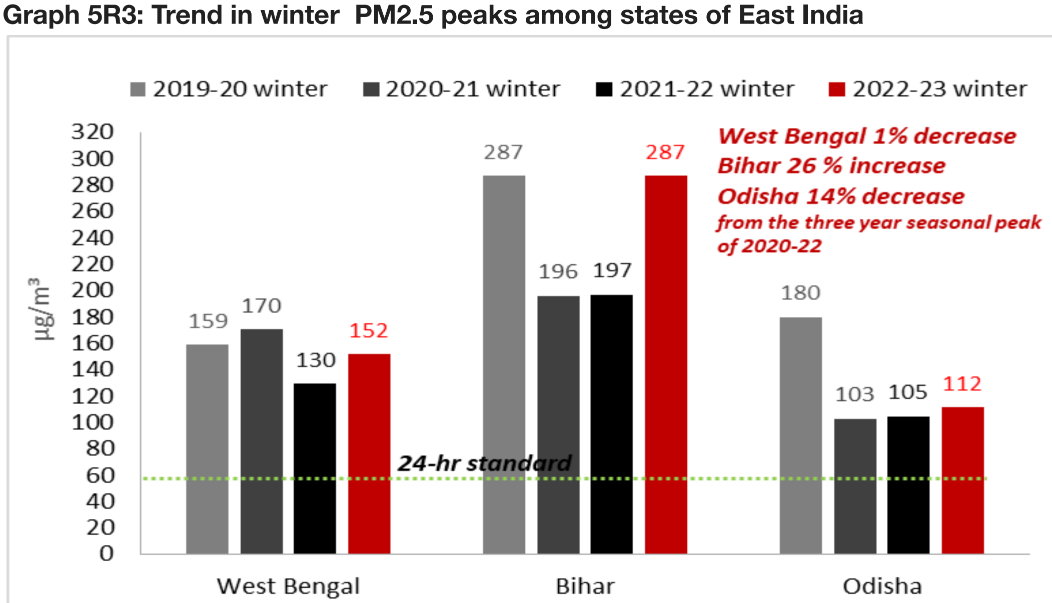
Graph 5R2: Trend in winter PM2.5 levels among states of East India



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of CPCB real-time data

<u>Peak pollution is dangerously high in all states of East India</u>: In absolute concentration terms, Bihar daily peak PM2.5 of 287 µg/m^3 was the highest among states of East India. West Bengal's peak PM2.5 was 152 µg/m^3 and Odisha's peak was 112 µg/m^3 this winter (See *Graph 5R3: Trend in winter PM2.5 peaks among states of East India*). In the long term, the seasonal peak in West Bengal this winter has been 1 per cent better than the mean of previous three winter peaks, while Bihar registered 26 per cent increase and Odisha 14 per cent increase in their peak compared to the mean of previous three winter peaks.

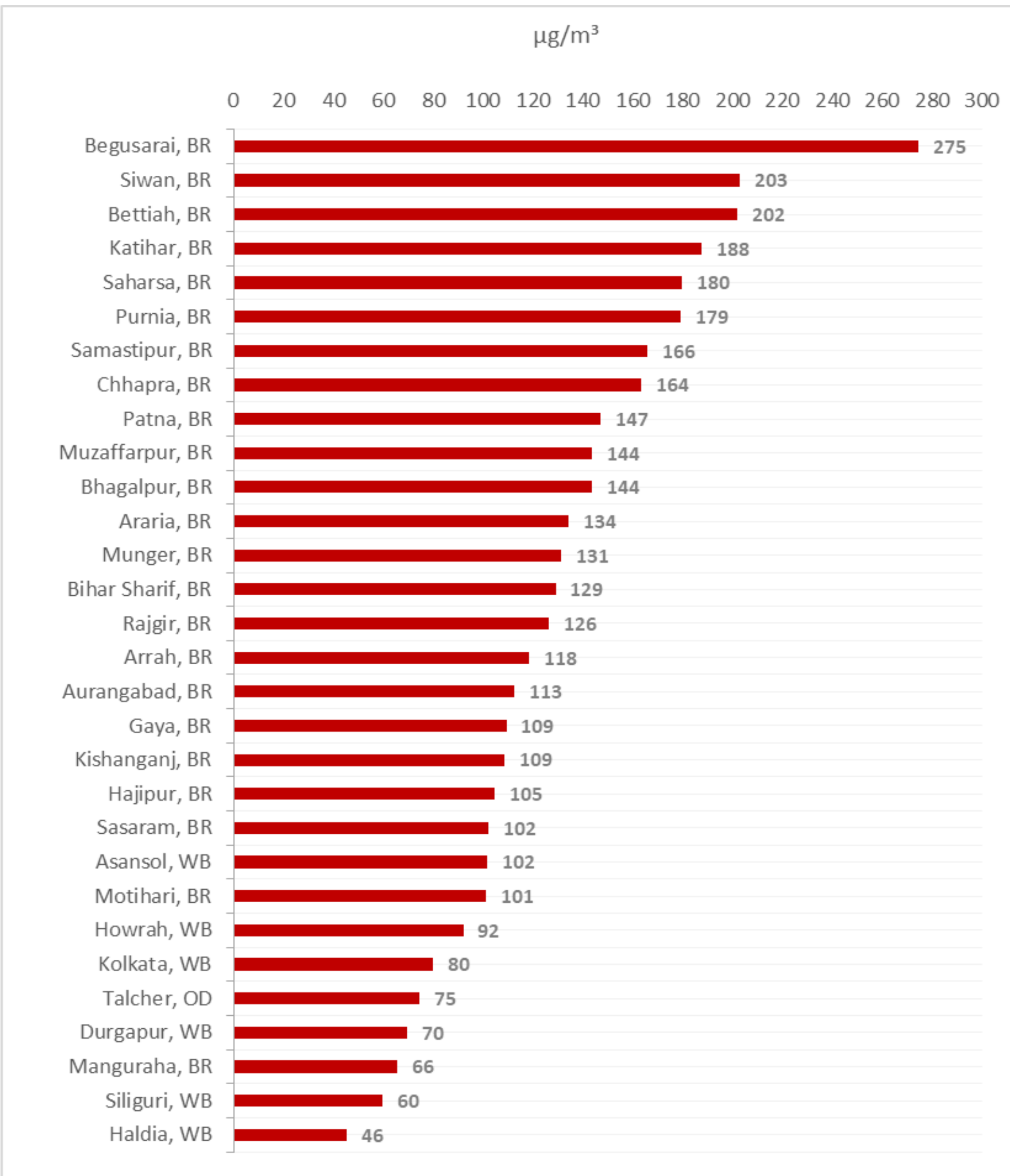
Graph 5R3: Trend in winter PM2.5 peaks among states of East India



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of CPCB real-time data

<u>Smaller cities of Bihar are most polluted in the region</u>: Begusarai was the most polluted city in East India with average PM2.5 of 275 µg/m³. It was followed by Siwan with 203 µg/m³, Bettiah with 202 µg/m³, Katihar at 188 µg/m³, and Saharsa at 180 µg/m³. All the top 20 most polluted cities of East India are located in Bihar (See *Graph 5R4: Winter PM2.5 level among East Indian cities*). Asansol with the winter average of 102 µg/m³ was the most polluted city in West Bengal and is followed by Howrah (*92* µg/m³) as the second most polluted. Talcher (*75* µg/m³) was the most polluted city in Odisha but since only two cities have real-time monitors with adequate data for assessment therefore they may be more polluted cities in the state but they are out of the scope of this analysis. Haldia in West Bengal was the least polluted city with PM2.5 average of 46 µg/m³ followed by Siliguri and Manguraha, Bihar with winter average of 60 µg/m³ and 66 µg/m³ respectively.

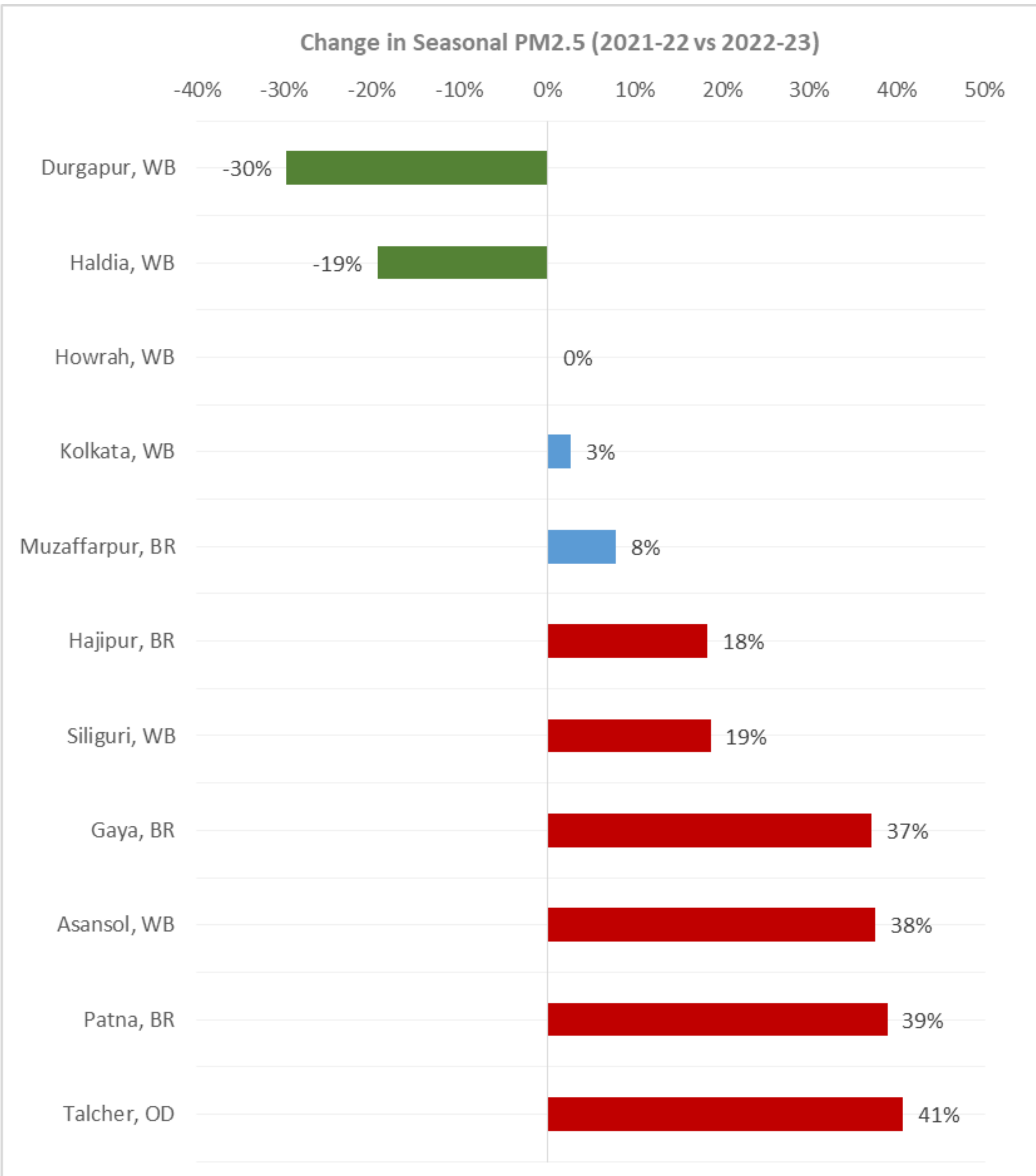
Graph 5R4: Winter PM2.5 level among East Indian cities



Note: Cities with multiple stations are represented by the mean of all city stations. PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of CPCB real-time data

<u>Patna registered the most increase in winter pollution this winter among major East Indian cities</u>: Talcher in Odisha and Patna in Bihar were the worst performers and registered an increase of 41 per cent and 39 per cent from last year respectively. They were followed by Asansol in West Bengal and Gaya in Bihar with an increase of 38 per cent and 37 per cent respectively. (See *Graph 5R5: Change in winter PM2.5 level among East Indian cities 2021-22 vs 2022-23*). Howrah (zero per cent), Kolkata (3 per cent) and Muzaffarpur (8 per cent) registered nil to marginal increase in pollution level this season compared to previous winter. Haldia and Durgapur are the only two cities that have shown improvement in air quality this season compared to the same period previous year. Durgapur registered the most improvement with 30 per cent and Haldia registered with 19 per cent lower PM2.5 compared to previous year.

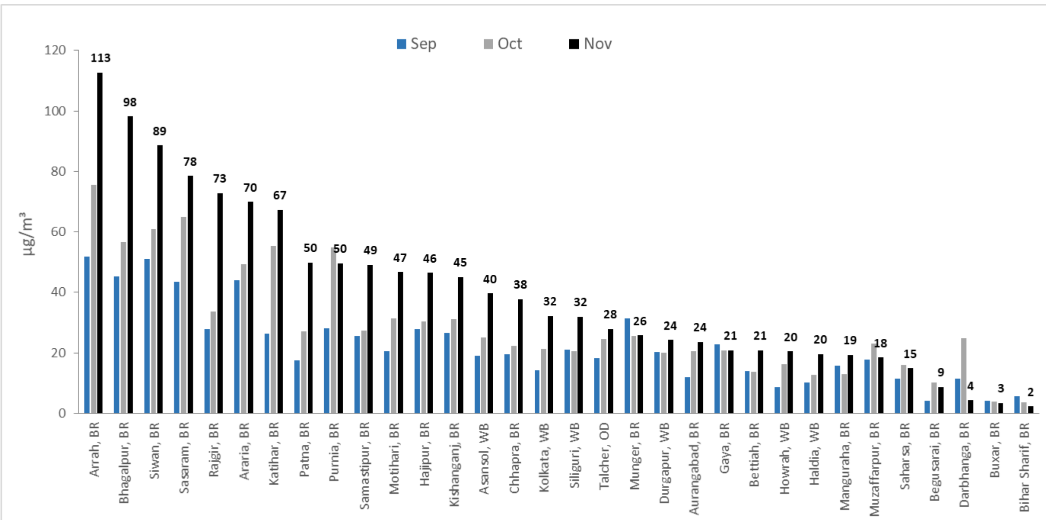
Graph 5R5: Change in winter PM2.5 level among East Indian cities 2021-22 vs 2022-23



Note: Cities with multiple stations are represented by the mean of all city stations. Cities with data in both 2021 and 2022 are compared. PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of CPCB real-time data

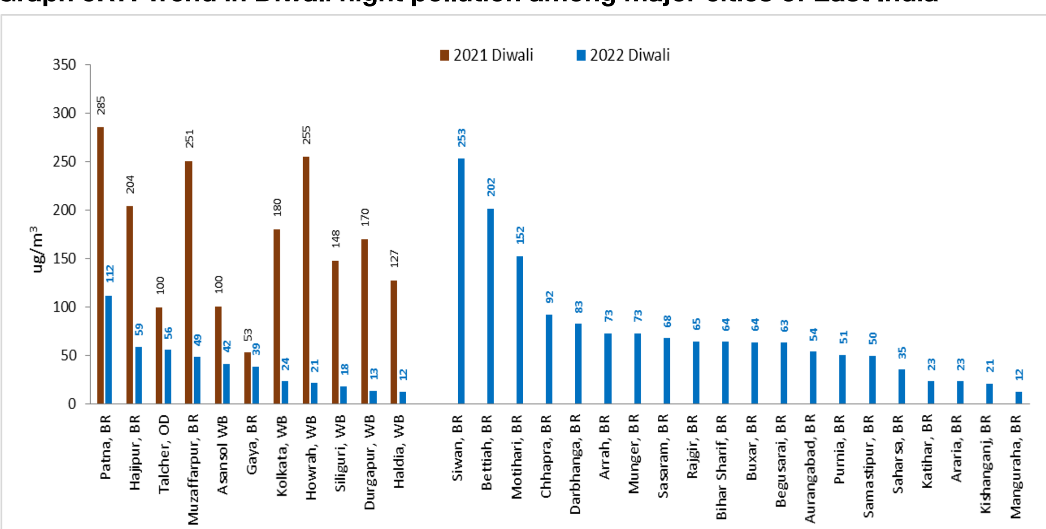
<u>Increasing levels of Nitrogen dioxide (NO2) during November</u>: There is a significant increase in the amount of NO2 in air during November compared to October and September. NO2 comes entirely from combustion sources and significantly from vehicles. Patna has registered the greatest increase of 2.9 times maximum build-up of NO2 between September and November. Katihar and Rajgir each registered 2.6 times increase in NO2. Motihari, Kolkata and Howrah all have registered 2.3 times increase in NO2 from September to November. In absolute concentration terms, Arrah in Bihar registered the highest NO2 average of 113 µg/m³ (See *Graph 5R6: Trend in NO2 levels among cities of East India*). It is followed by Bhagalpur with 98 µg/m³ and Siwan with 89 µg/m³. Among West Bengal cities Asansol with a monthly average of 40 µg/m³ was the most polluted in the region.

Graph 5R6: Trend in NO2 levels among cities of East India



Note: NO2 values for cities with more than one monitoring station is based on the average of all stations that have adequate data. Data up till 30 November 2022.
Source: CSE analysis of real-time data from CPCB portal

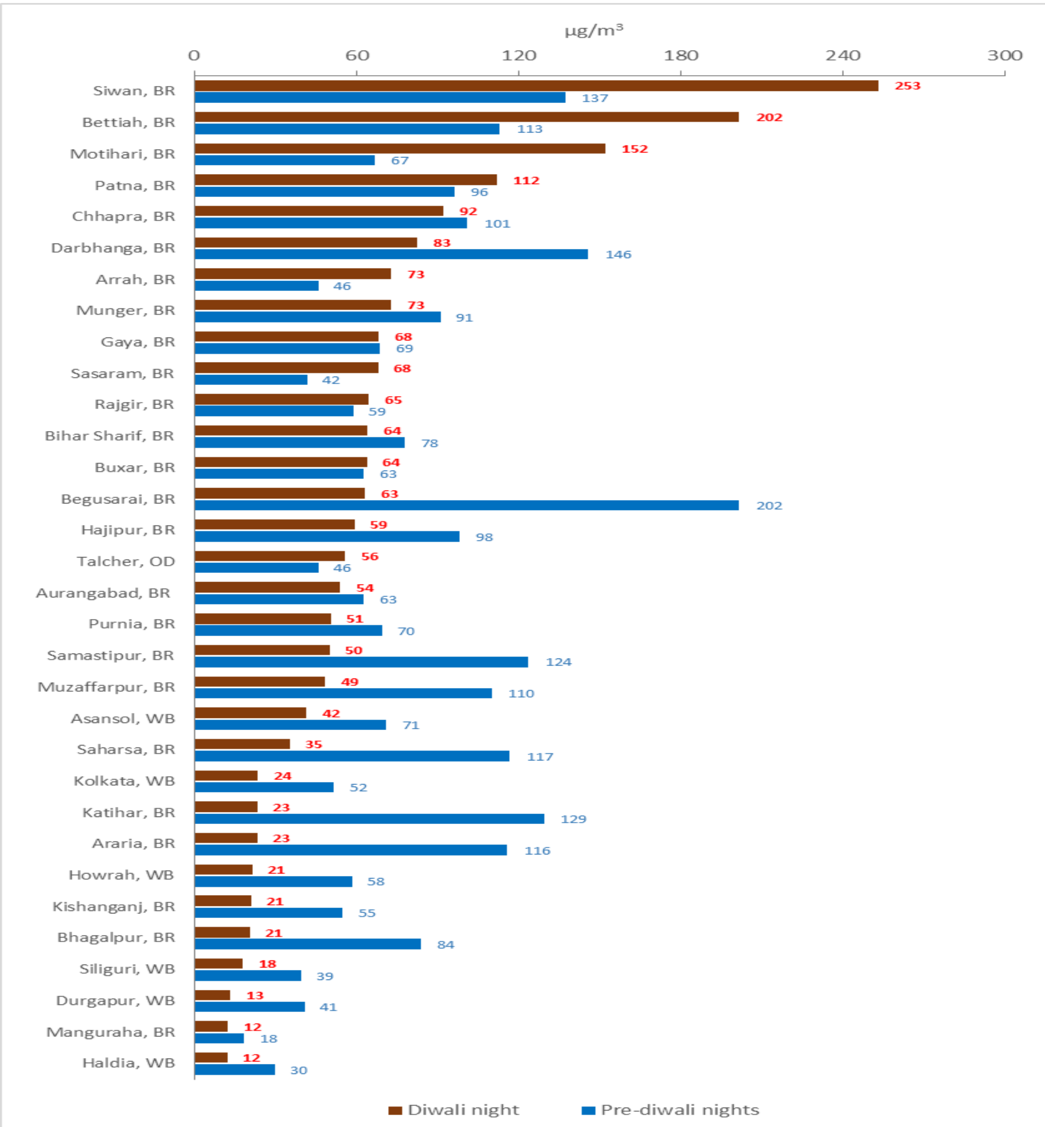
Graph 5R7: Trend in Diwali night pollution among major cities of East India



Note: PM2.5 values for cities with more than one monitoring station is based on the average of all stations that have adequate data for complete assessment period. Diwali night is considered from 8.00PM to 8.00AM on 4 Nov 2021 and 24 Oct 2022.
Source: CSE analysis of real-time data from CPCB portal

Diwali pollution is highest among small towns of Bihar in East Indian Region: This Diwali is least polluted compared to last year's Diwali for all major cities in the region. Cities of Bihar had seen the maximum increase on Diwali night (See *Graph 5R7: Trend in Diwali night pollution among major cities of East India*). Pollution level on Diwali night (8pm to 8am) in cities shot up by 0.2 -- 2.3 times the average level recorded seven nights preceding Diwali (See *Graph 5R8: Diwali night pollution among cities of East India*). This Diwali nine out of 32 stations show an increase in pollution on the day of Diwali, while other stations have their pollution level at its greatest before Diwali. Motihari in Bihar saw the greatest jump of 2.3-times higher PM2.5 level on Diwali night at 152 µg/m^3. It is followed by Siwan and Bettiah each with 1.8-times higher PM2.5 concentration. Bihar cities dominate in the most polluted Diwali night list. Among West Bengal cities Asansol records Diwali night PM2.5 levels at 42 µg/m^3. Haldia and Manguraha each with 12 µg/m^3 had the least polluted Diwali night in the region followed by Durgapur with 13 µg/m^3.

Graph 5R8: Trend in Diwali night pollution among major cities of East India



Note: PM2.5 values for cities with more than one monitoring station is based on the average of all stations that have adequate data for complete assessment period. Diwali night is considered from 8.00PM October 24 to 8.00AM October 25. Pre-diwali night is an average of seven nights (8.00PM-8.00AM) preceding Diwali.
Source: CSE analysis of real-time data from CPCB portal

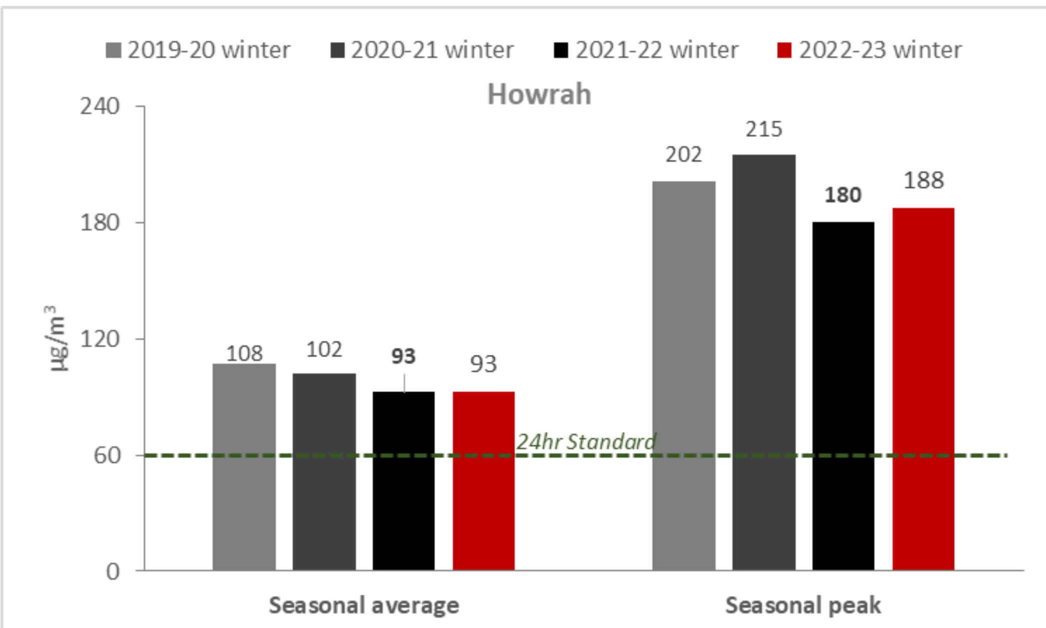
Key findings: Cities

Note: This does not include Kolkata as it has been covered in the mega-cities analysis under Report

West Bengal: Howrah

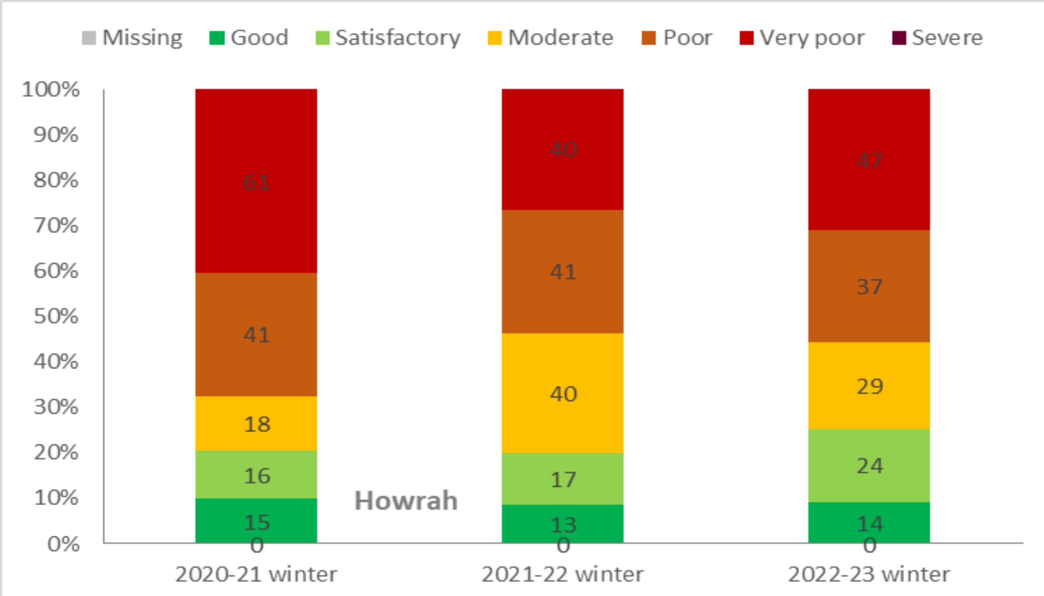
Winter pollution level in Howrah this season has been 8 per cent lower than the mean of previous three winters but is still considerably higher than the standard. Similarly, there has been a 6 per cent decline in winter peak compared to the mean of peaks of the previous three winters (See *Graph 5R11: PM2.5 winter trend in Howrah*). AQI categorization shows that the city's air quality has not deteriorated to severe days in the last three years but the number of days with poor and very poor air quality has increased this winter compared to last year. However, it has not been as bad as winter of 2020-21 (See *Graph 5R12: PM2.5 AQI trend in Howrah*).

Graph 5R11: PM2.5 winter trend in Howrah



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 5R12: PM2.5 AQI trend in Howrah

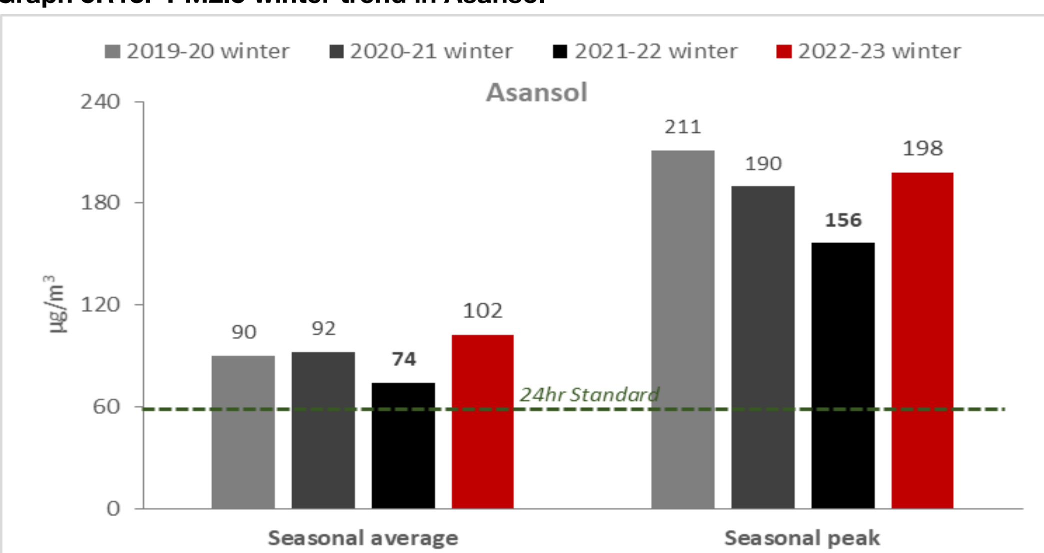


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment periods. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

West Bengal: Asansol

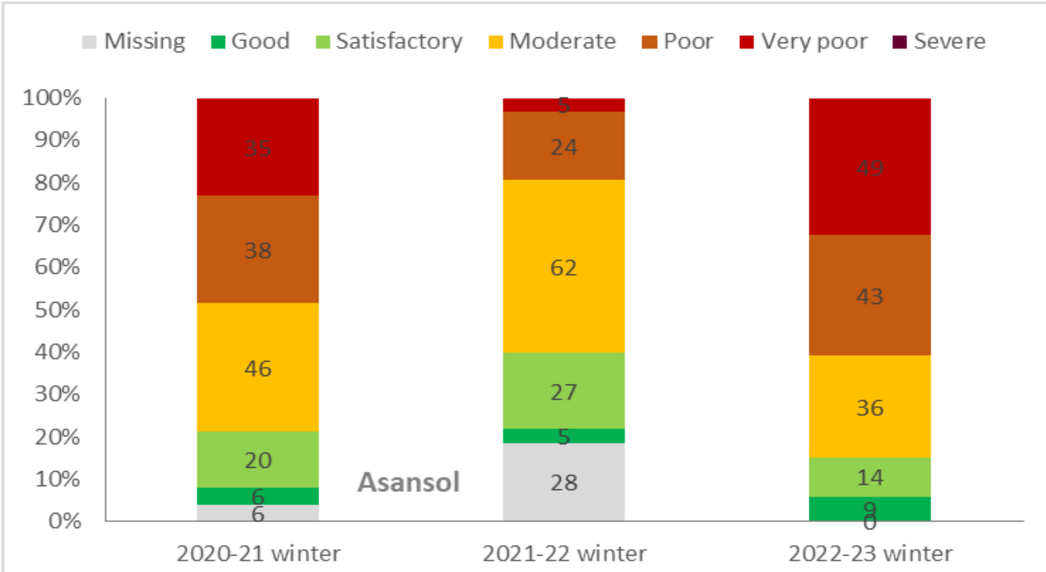
Winter pollution level in Asansol this season has been 20 per cent higher than the mean of previous three winters and with a seasonal average of 102 µg/m³ the city's air quality is considerably higher than the standard. Similarly, there has been a 6 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 5R13: PM2.5 winter trend in Asansol*). AQI categorization shows that the city's air quality has deteriorated this winter with 92 days with poor and very poor air quality, a considerable increase compared to previous two winters (See *Graph 5R14: PM2.5 AQI trend in Asansol*).

Graph 5R13: PM2.5 winter trend in Asansol



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 5R14: PM2.5 AQI trend in Asansol

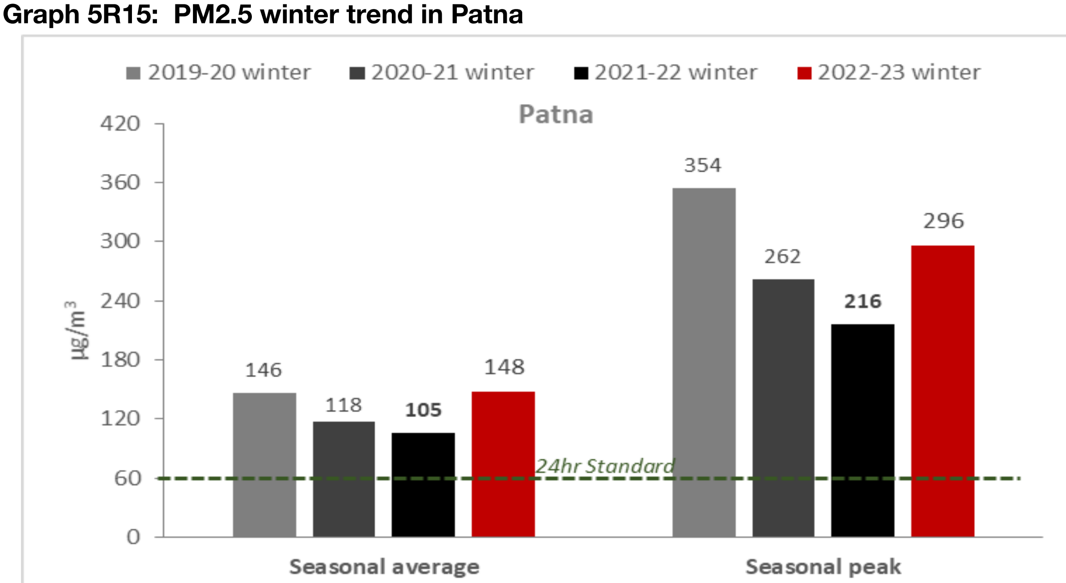


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Bihar: Patna

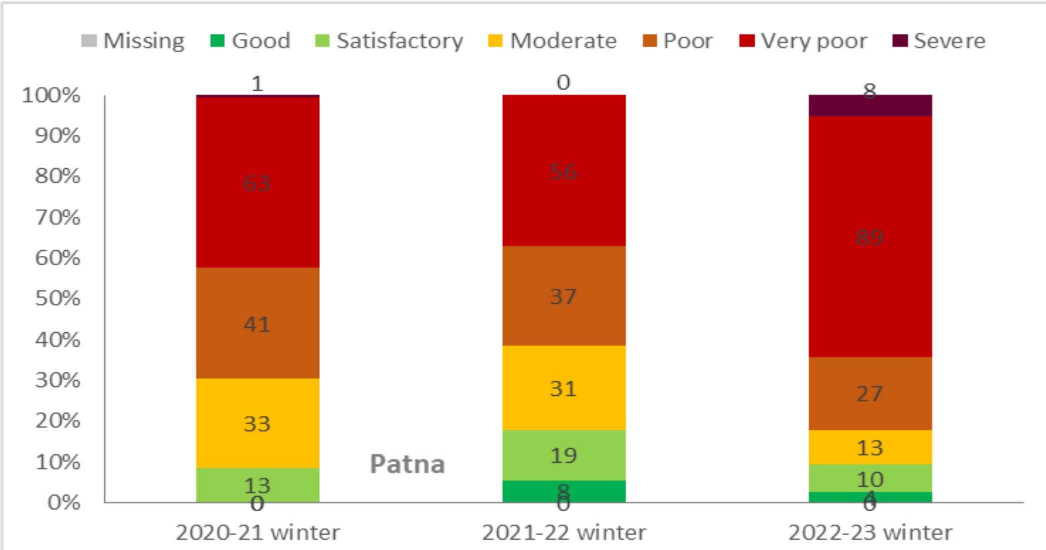
Winter pollution level in Patna this season has been 20 per cent higher than the mean of previous three winters and with a seasonal average of 148 µg/m^3 the city's air quality is considerably higher than the standard. Similarly, there has been a 7 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 5R15: PM2.5 winter trend in Patna*). AQI categorization shows that the city's air quality has deteriorated this winter with 8 days of severe air quality and 89 days of very poor air quality, a considerable increase compared to previous two winters (See *Graph 5R16: PM2.5 AQI trend in Patna*). There had been only one day of severe air quality in the city in the previous two winters.

Graph 5R15: PM2.5 winter trend in Patna



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 5R16: PM2.5 AQI trend in Patna

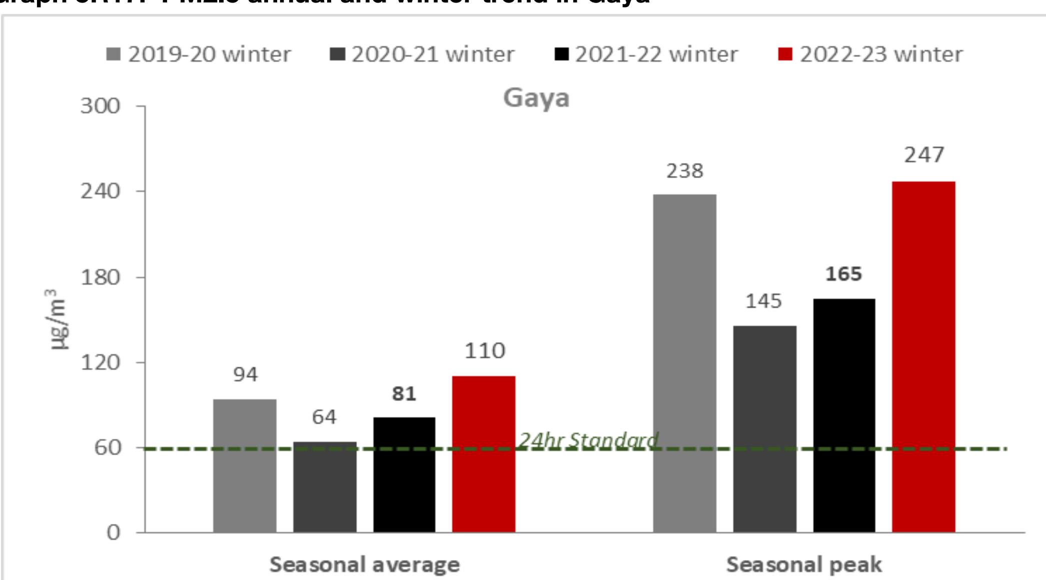


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Bihar: Gaya

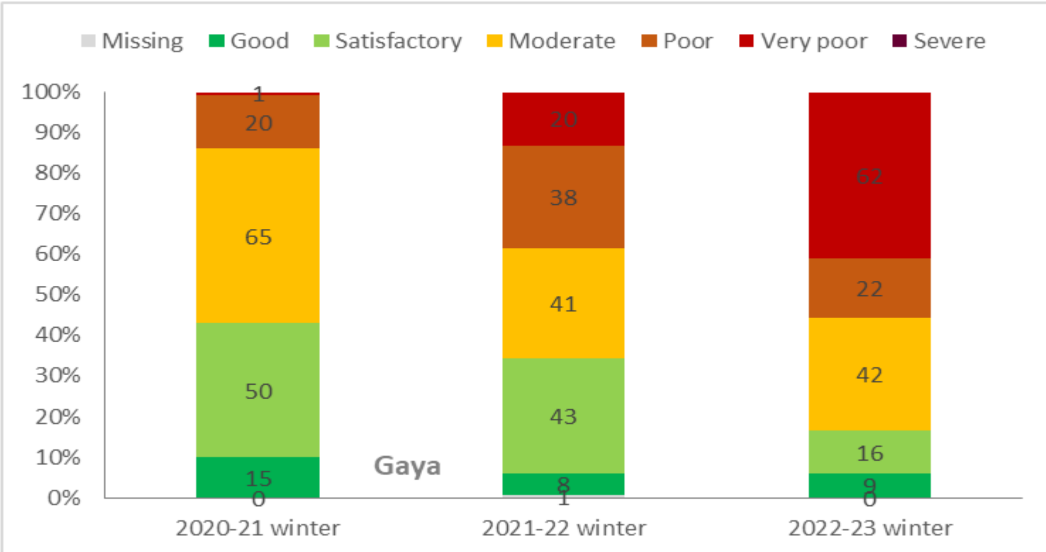
Winter pollution level in Gaya this season has been 39 per cent higher than the mean of previous three winters and with a seasonal average of 110 µg/m^3 the city's air quality is considerably higher than the standard. Similarly, there has been a 35 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 5R17: PM2.5 winter trend in Gaya*). AQI categorization shows that the city's air quality has deteriorated this winter with 62 days of very poor air quality, a considerable increase compared to previous two winters (See *Graph 5R18: PM2.5 AQI trend in Gaya*). There were 20 "very poor" days in the 2021-22 winter and just one "very poor" day in the 2020-21 winter.

Graph 5R17: PM2.5 annual and winter trend in Gaya



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 5R18: PM2.5 AQI trend in Gaya

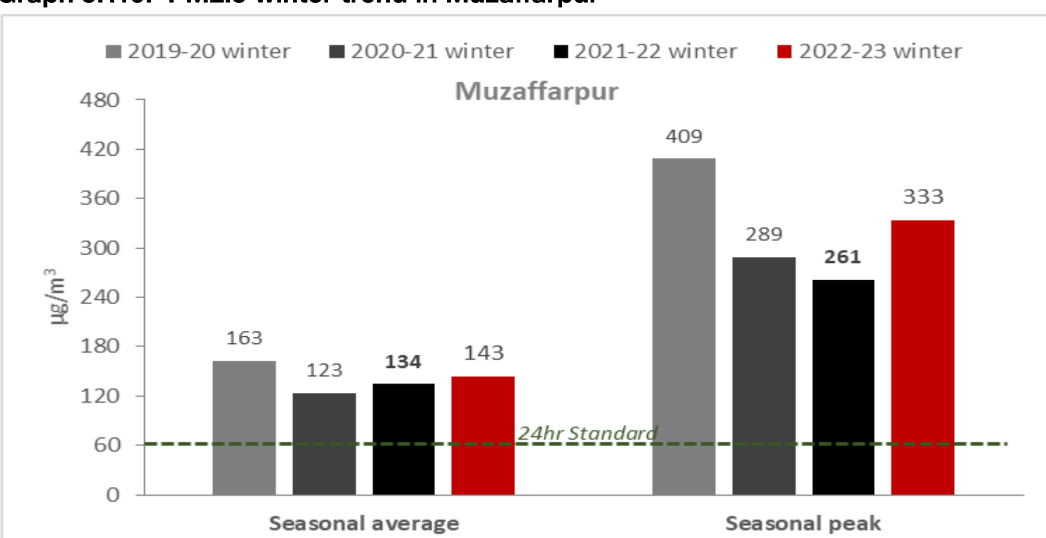


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Bihar: Muzaffarpur

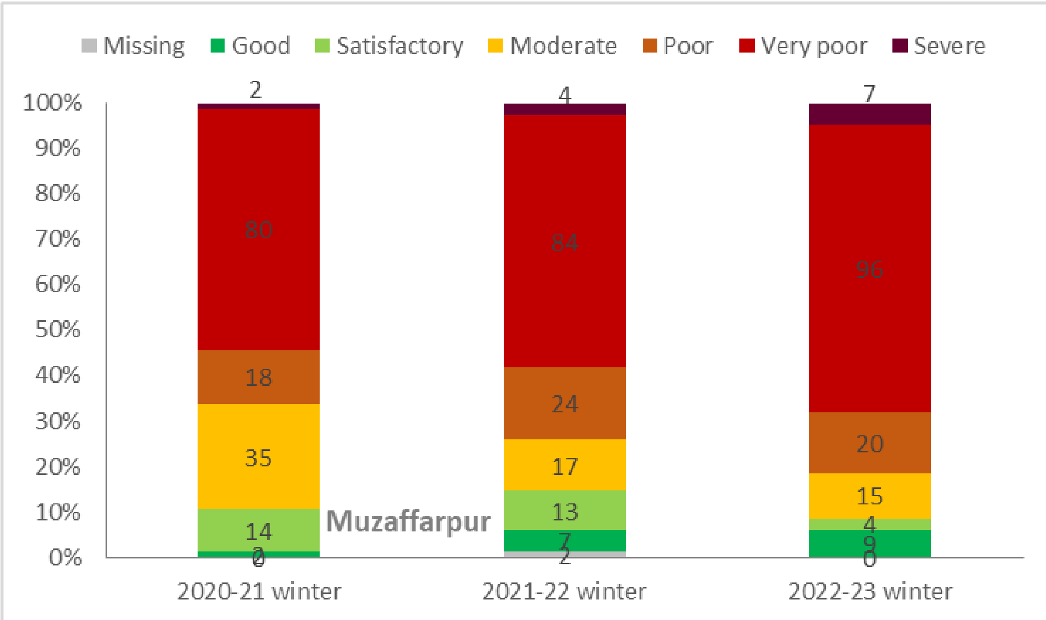
Winter pollution level in Muzaffarpur this season has been 2 per cent higher than the mean of previous three winters and with a seasonal average of 143 µg/m^3 the city's air quality is considerably higher than the standard. Similarly, there has been a 4 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 5R19: PM2.5 winter trend in Muzaffarpur*). AQI categorization shows that the city's air quality has deteriorated considerably this winter with 7 days of severe air quality and 96 days of very poor air quality, a considerable increase compared to previous two winters (See *Graph 5R20: PM2.5 AQI trend in Muzaffarpur*). There were 4 "severe" days in the 2021-22 winter and just 2 "severe" days in the 2020-21 winter.

Graph 5R19: PM2.5 winter trend in Muzaffarpur



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 5R20: PM2.5 AQI trend in Muzaffarpur



Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Annexure 5R

Winter PM2.5 level at station levels among East Indian cities

Station	State	2021-22 winter	2022-23 winter
Begusarai_DRCC_Anandpur	Bihar		275
Siwan _ChitraguptaNagar	Bihar	201	203
Bettiah_KamalnathNagar	Bihar	160	202
Darbhanga_TownHall	Bihar	152	200
Katihar_Mirchaibari	Bihar	153	188
Saharsa _PoliceLine	Bihar	143	180
Purnia_MariamNagar	Bihar	157	179
Patna_Samanpura	Bihar	104	175
Samastipur_DMOffice	Bihar		166
Muzaffarpur_BuddhaColony	Bihar	113	165
Chhapra _DarshanNagar	Bihar	183	164
Patna_Muradpur	Bihar	78	154
Gaya_Kareemganj	Bihar	160	151
Patna_IGSC	Bihar	169	150
Bhagalpur_Mayaganj	Bihar	138	150
Patna_Danapur	Bihar	102	144
Patna_RajbansiNagar	Bihar	136	142
Bhagalpur_DMOffice	Bihar	140	142
Buxar _CentralJail	Bihar	175	140
Araria _KharahiyaBasti	Bihar	108	134
Muzaffarpur_MIT	Bihar	188	133
Munger _TownHall	Bihar	179	131
Muzaffarpur_Collectorate	Bihar	139	129
BiharSharif_DMColony	Bihar	136	129
Rajgir_DangiTola	Bihar	142	126
Howrah_Ghusuri	West Bengal	140	126
Patna_Shikarpur	Bihar	85	122
Arrah_New_DMOffice	Bihar	114	118
Gaya_Collectorate	Bihar	79	118
Aurangabad_GurdeoNagar	Bihar		113
Kishanganj_SDMOffice	Bihar	164	109
Hajipur_IndustrialArea	Bihar	87	105
Sasaram _DadaPeer	Bihar	134	102
Asansol	West Bengal	73	102

Station	State	2021-22 winter	2022-23 winter
Motihari_GandakColony	Bihar	139	101
Kolkata_Victoria	West Bengal	69	96
Kolkata_Jadavpur	West Bengal	78	90
Kolkata_RBUniversity	West Bengal	114	89
Kolkata_Bidhannagar	West Bengal	77	85
Kolkata_Ballygunge	West Bengal	81	84
Howrah_Padmapukur	West Bengal	64	77
Howrah_BelurMath	West Bengal	75	77
Talcher_Coalfields	Odisha	53	75
Durgapur	West Bengal	97	70
Manguraha _FRH	Bihar	53	66
Kolkata_RabindraSarobar	West Bengal	60	63
Gaya_SFTI	Bihar	45	61
Siliguri	West Bengal	50	60
Kolkata_FortWilliam	West Bengal	76	57
Haldia	West Bengal	56	46

Note: 1 October- 28 February average is based on mean of daily averages. All values are in µg/m^3. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB real-time data

Report 6

Central Indian winter pollution: The problem of low monitoring

Towards the end of winter season, the Urban Lab at the Centre for Science and Environment (CSE) has conducted an extensive analysis of the air quality trends in West India, with a specific focus on the states of Maharashtra and Gujarat. The objective has been to understand behaviour of the winter pollution in this region this October, 2022 to February, 2023. In these states, winter pollution typically sets in during late November and early December when the cooler and calmer conditions trap locally generated high levels of 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 part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on air quality.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019, 2020, 2021, 2022 and 2023. This analysis is based on the real time data available from the current working air quality monitoring stations in Central India. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis. This analysis covers 18 continuous ambient air quality monitoring stations (CAAQMS) spread across 17 cities in two states: two stations in Gwalior and one station each in Bhopal, Damoh, Dewas, Indore, Jabalpur, Katni, Maihar, Mandideep, Pithampur, Ratlam, Sagar, Satna, Singrauli, Ujjain, Bhilai, and Bilaspur.

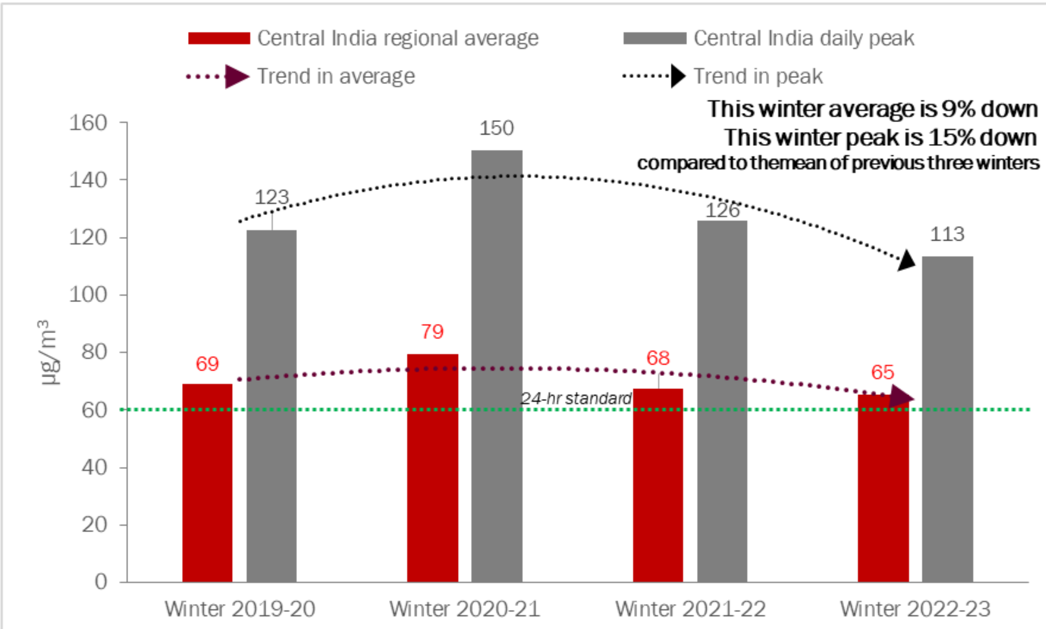
Air quality monitoring is still very limited in the central region. MP cities have data available for over four years. But real time monitors in Chhattisgarh became operational only in the later half of 2021 which limits the possibility of assessing long term trends. Therefore data is indicative of the current status of air quality and seasonal variation in particulate pollution in medium and smaller cities. Many new stations have been added in October 2022: four stations in Raipur, one station each in Bhopal and Sagar, two stations each in Gwalior, Bhilai, and Korba.

Analysis shows that the regional winter pollution level in Central India has been the lowest compared to the previous four years. Worsening air quality is spatially and temporally synchronised across Central India with Singrauli and Gwalior having the worst air quality in the region. Nitrogen dioxide (NO2) pollution is also high in these cities with Indore recording the highest November average at 84 $\mu g/m^3$ among the cities of this region.

Key findings: Regional

This winter was the least polluted in the last four years in Central India: The average PM2.5 level across cities of Central India stood at 65 µg/m^3 this winter (See *Graph 6R1: Trend in Central India's winter PM2.5 average*). It is 9 per cent lower than the mean of the previous three winters. Daily peak for the region this winter happened on 3 January 2023 and it was 113 µg/m^3. It was 15 per cent lower than the mean of the previous three winter peaks.

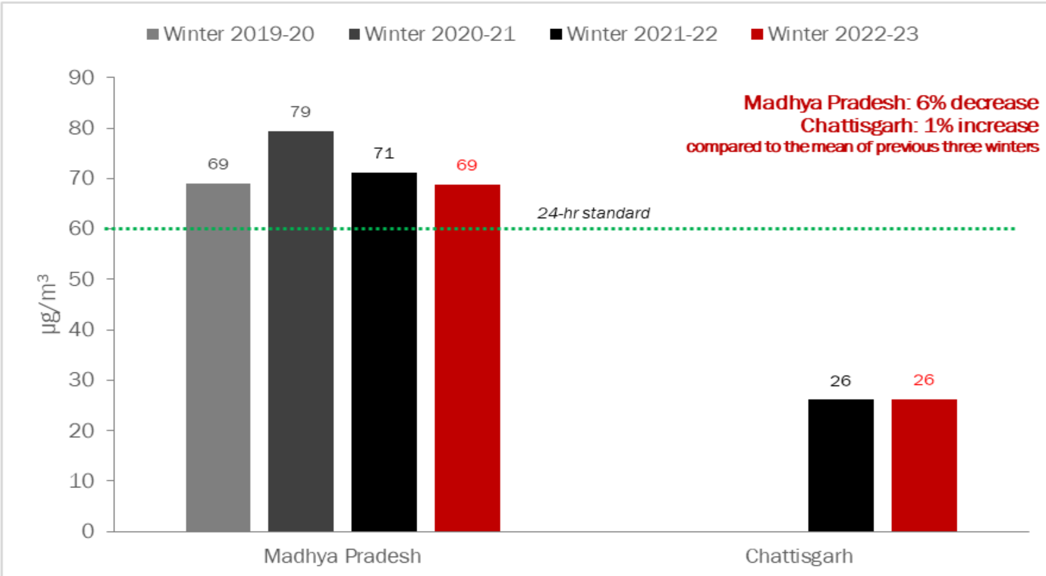
Graph 6R1: Trend in Central India's winter PM2.5 average



Note: Winter is defined as 1 October-28 February. Winter average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data.

Madhya Pradesh is more polluted but limited monitoring in Chhattisgarh might be hiding pollution hotspots: Winter pollution level in Madhya Pradesh fell by 6 per cent compared to the mean of the previous three winters. Winter pollution has been declining in Maharashtra since the 2021-22 winter and stood at 69 µg/m^3 this winter. Monitoring only started in Chhattisgarh in 2021 and data for its two working CAAQMS stations is of suspicious nature as they don't show fluctuation of PM2.5 level across seasons (*Graph 6R2: Trend in winter PM2.5 levels for states of Central India*).

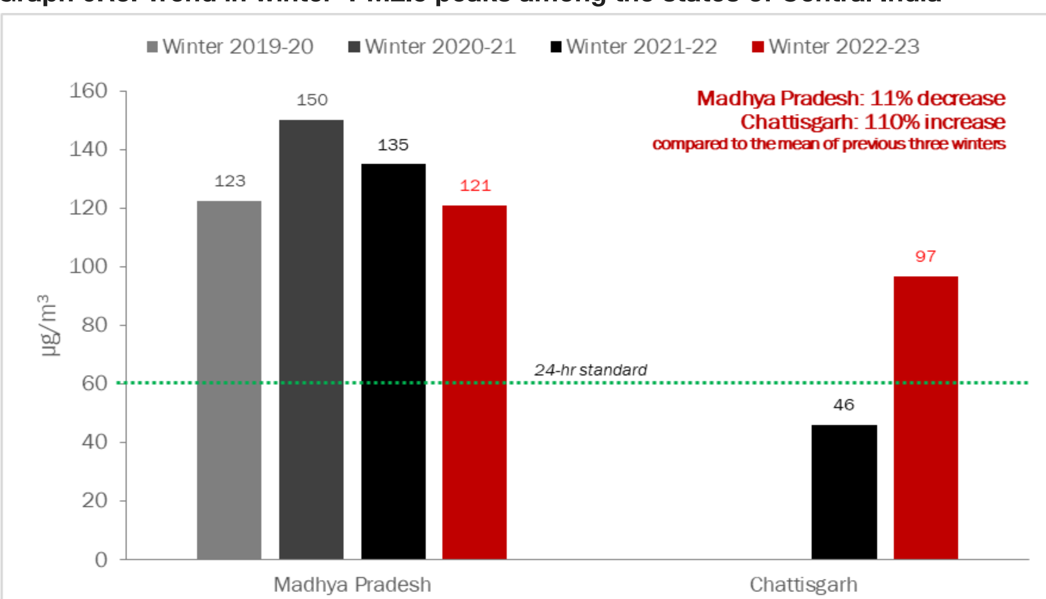
Graph 6R2: Trend in winter PM2.5 levels for states of Central India



Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

<u>Peak pollution is at its lowest for Madhya Pradesh but it is rising in Chhattisgarh</u>: Madhya Pradesh had its peak daily PM2.5 of 121 µg/m^3 on 3 January 2023. This was the lowest regional peak in the last four years and was 11 per cent lower than the mean of the previous three winter peaks. Chhattisgarh's peak daily PM2.5 a little later on 13 January 2023. Chhattisgarh's daily PM2.5 peak stood at 97 µg/m^3, which is more than double of its 2021-22 winter peak (See *Graph 6R3: Trend in winter PM2.5 peaks among the states of Central India*).

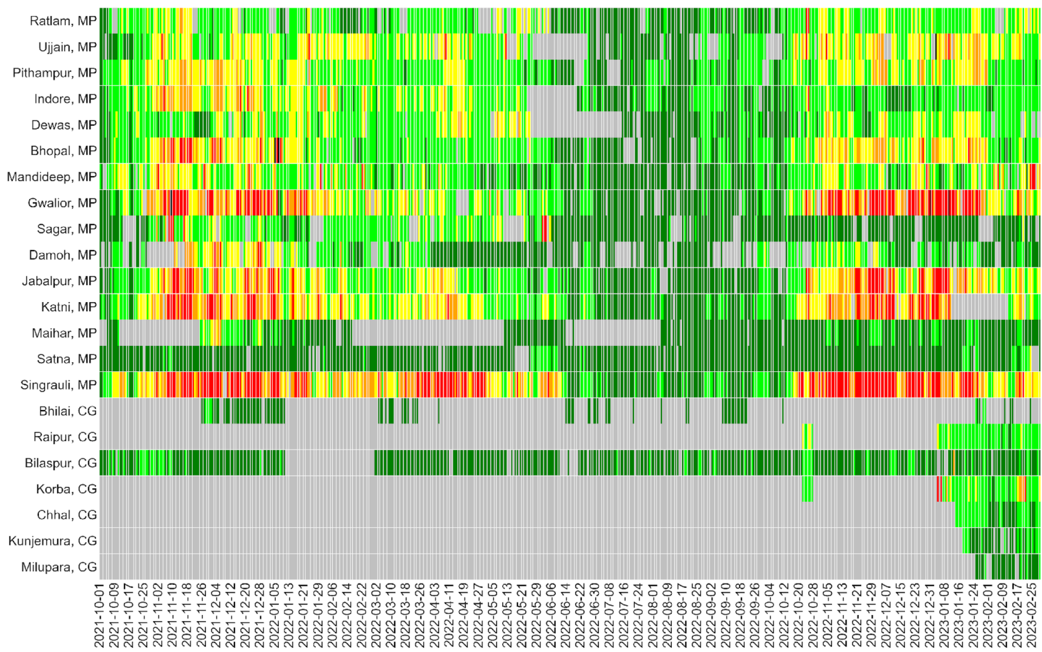
Graph 6R3: Trend in winter PM2.5 peaks among the states of Central India



Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

Winter air gets dirty across cities of Central India in a synchronised way: Worsening of air quality starts mid-October across Central India in a synchronised fashion as weather starts to cool down and winds get slow (See *Graph 6R4: Air quality heat map of Central Indian cities*). But the analysis is hampered by poor data quality among the stations of the region, especially among the stations of Chhattisgarh. Further, data from stations at Sagar, Satna, Maihar and Bilaspur shows abnormally low and stable numbers across all seasons which are highly unlikely given then known seasonal fluctuations in PM2.5 levels. Therefore, it is advisable to ignore data from these stations unless ground investigation is carried out to establish authenticity of the data reported from these three cities. It should be additionally noted that stations in question in Sagar, Maihar and Bilaspur are operated by private industry (steel and cement plants) and not the state pollution control boards.

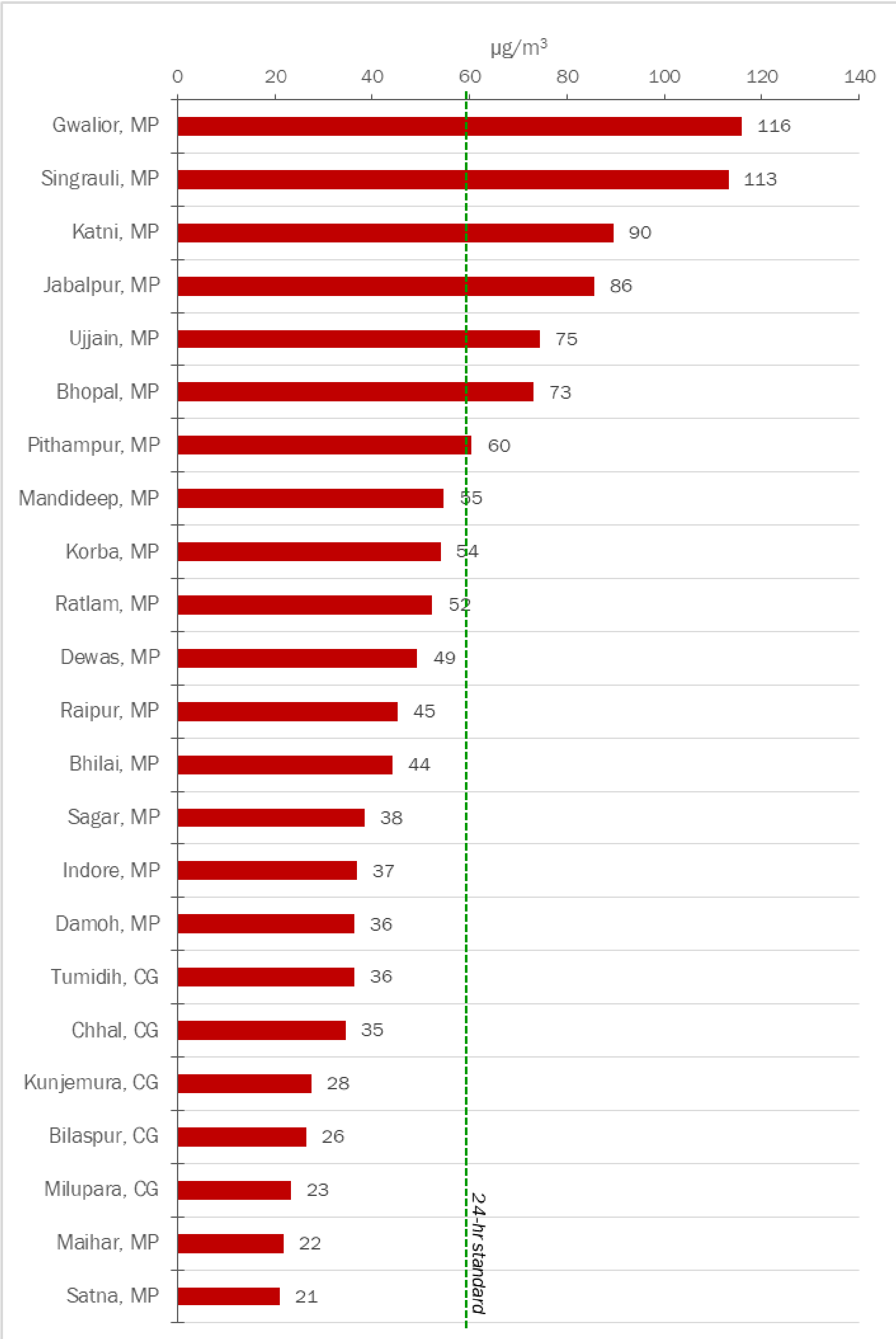
Graph 6R4: Air quality heat map of Central Indian cities



Note: Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB real-time data

Gwalior has the most polluted air in Central India followed by Singrauli: Gwalior was the most polluted city in Central India with an average PM2.5 of 116 µg/m³. It was followed by Singrauli with 113 µg/m³, and Katni with 90 µg/m³ (See *Graph 6R5: Winter PM2.5 level among Central Indian cities).* Jabalpur (86 µg/m³), Ujjain (75 µg/m³) and Bhopal (73 µg/m³) also registered high winter PM2.5 levels exceeding the 24-hr standard. Sagar and Maihar in MP reported data that computes to minimum PM2.5 averages in the region but given the suspect nature of data from these two stations, it cannot be confirmed that these cities have this low pollution in reality.

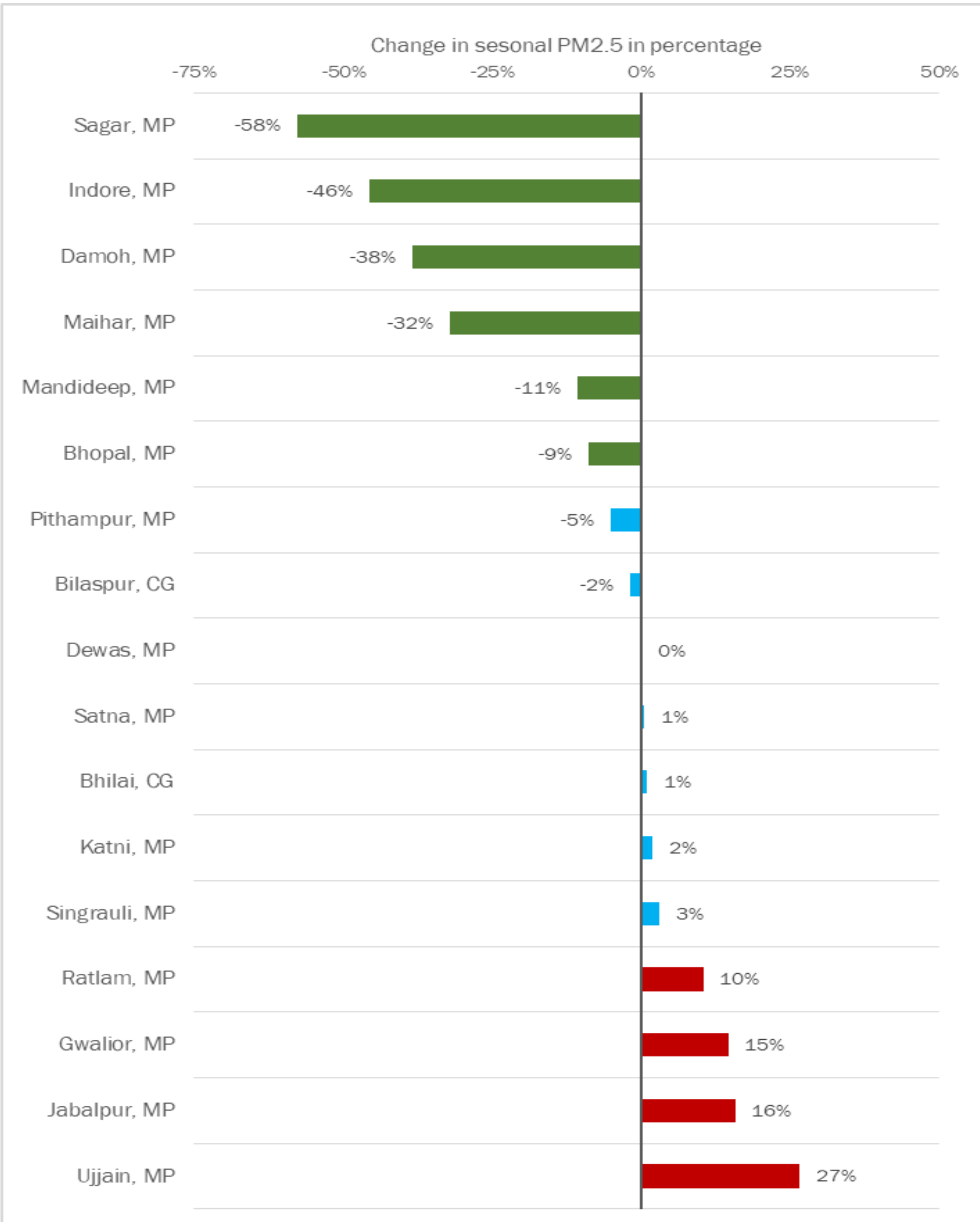
Graph 6R5: Winter PM2.5 level among Central Indian cities



Note: 1 October 2022-28 February 2023 average is based on mean of daily averages. Cities with multiple stations are represented by the mean of all city stations. Source: CSE analysis of CPCB real-time data

Ujjain and Jabalpur registered the most increase in pollution this winter: Winter pollution in Ujjain increased by 27 per cent compared to the previous winter. It is followed by Jabalpur with 16 per cent and Gwalior with 15 per cent higher PM2.5 compared to the previous year. (See *Graph 6R6: Change in winter PM2.5 levels among Central Indian cities 2021-22 vs 2022-23*). Indore was the best performer and registered a fall of 46 per cent from last winter. Bhopal also registered an improvement of 9 per cent. Sagar and Maihar also made significant improvement but given the suspect nature of their data, their improvement in data cannot be fully trusted as reflective of ground reality.

Graph 6R6: Change in winter PM2.5 level among Central Indian cities 2021-22 vs 2022-23

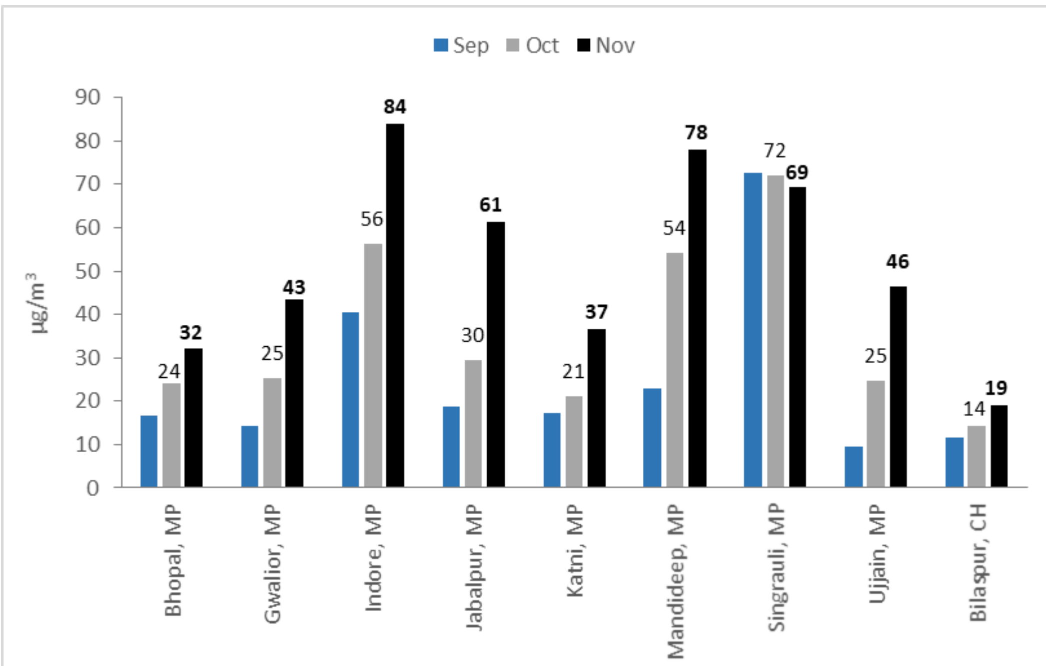


Note: 1 October-28 February 2021-22 and 2022-23 average is based on mean of daily averages. Cities with multiple stations are represented by the mean of all city stations. Cities with data in both 2021 and 2022 are compared.
Source: CSE analysis of CPCB real-time data

Increasing levels of Nitrogen dioxide (NO2) during November: There is a significant increase in the amount of NO2 in air during November compared to October and September. NO2 comes entirely from combustion sources and significantly from vehicles. Ujjain has registered the greatest increase of 4.8 times maximum build-up of NO2 between September and November. Mandideep has registered 3.4 times, Jabalpur and Gwalior have registered 3.3 times and 3.1 times increase in NO2 from September to November.

In absolute concentration terms, In Madhya Pradesh, Indore registered the highest NO2 average of 84 µg/m^3 (See *Graph 6R7: Trend in NO2 levels among sub-regions of Central India*). It is followed by Mandideep with 78 µg/m^3 and Singrauli with 69 µg/m^3. Among Chhattisgarh cities Bilaspur with a monthly average of 19 µg/m^3 was the most polluted in the region.

Graph 6R7: Trend in NO2 levels among sub-regions of Central India



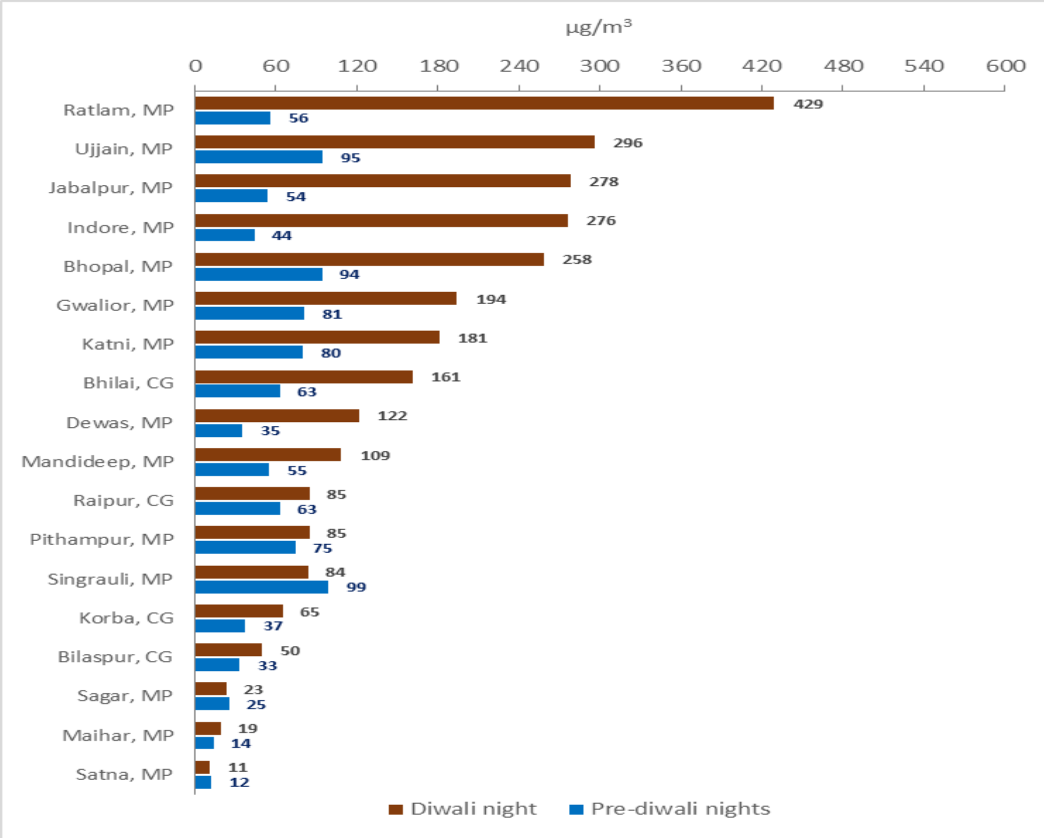
Note: NO2 values for sub-regions are based on the average of citywide values of all the cities in that region. NO2 values for cities with more than one monitoring station is based on the average of all stations that have continuous and adequate data for complete assessment period. Data up till 30 November 2022.
Source: CSE analysis of real-time data from CPCB portal

Diwali pollution is highest among cities of Madhya Pradesh in the Central Indian Region: Pollution level on Diwali night (8pm to 8am) in cities shot up by 0.8 – 7.6 times the average level recorded seven nights preceding Diwali (See *Graph 6R8: Diwali night pollution among cities of Central India*). Ratlam in Madhya Pradesh saw the greatest jump of 7.6 times higher PM2.5 level on Diwali night at 429 µg/m^3. It is followed by Indore with 6.3 times higher PM2.5 concentration.

Madhya Pradesh cities dominate in the top 5 list of most polluted Diwali nights. Ujjain records the PM2.5 level even higher than the Delhi city, as high as 296 µg/m^3. Jabalpur and Bhopal with Diwali night PM2.5 levels recording levels with 278 µg/m^3 and 258 µg/m^3 respectively. Satna at 11 µg/m^3 had the least polluted Diwali night in the region followed by Maihar at 19 µg/m^3.

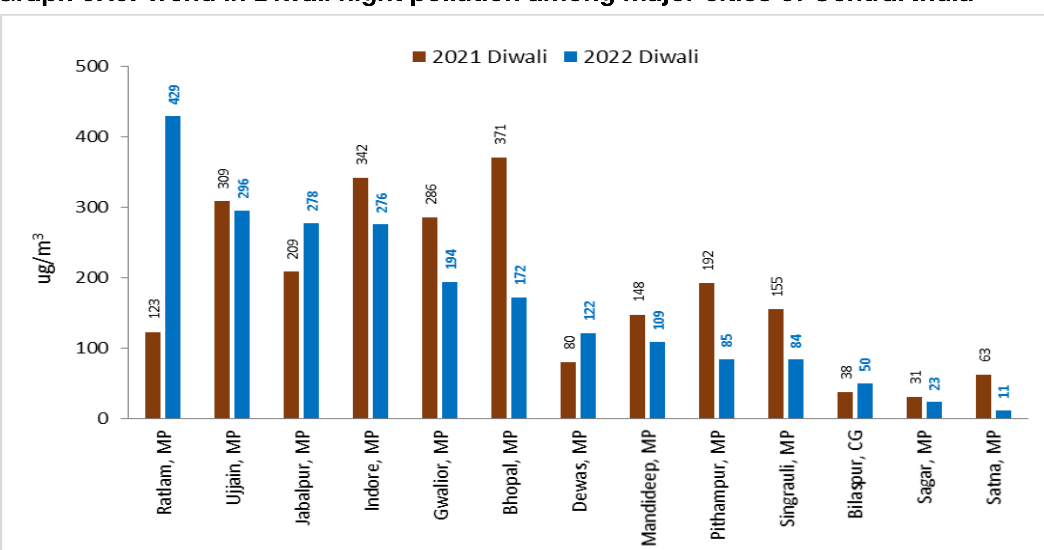
This Diwali is least polluted compared to last year's Diwali for all major cities in the region except Ratlam, Jabalpur, Dewas and Bilaspur. Cities of MP had seen the maximum increase on Diwali night (See *Graph 6R9: Trend in Diwali night pollution among major cities of Central India*).

Graph 6R8: Trend in Diwali night pollution among major cities of Central India



Note: PM2.5 values for cities with more than one monitoring station is based on the average of all stations that have continuous and adequate data for complete assessment periods. Diwali night is considered from 8.00PM October 24 to 8.00AM October 25. Pre- diwali night is an average of seven nights (8.00PM-8.00AM) preceding Diwali.
Source: CSE analysis of real-time data from CPCB portal

Graph 6R9: Trend in Diwali night pollution among major cities of Central India



Note: PM2.5 values for cities with more than one monitoring station is based on the average of all stations that have adequate data for complete assessment period. Diwali night is considered from 8.00PM to 8.00AM on 4 Nov 2021 and 24 Oct 2022.
Source: CSE analysis of real-time data from CPCB portal

Annexure 6R

Winter PM2.5 level at station levels among Central Indian cities

	Station	State	2021-22 winter	2022-23 winter
1	Bhilai_32Bungalows	Chhattisgarh		40
2	Bhilai_Civic_center	Chhattisgarh	22	22
3	Bhilai_Hathkoj	Chhattisgarh		50
4	Bilaspur_Mangala	Chhattisgarh	27	26
5	Chhal_NawaparaSECL	Chhattisgarh		35
6	Korba_Rampur	Chhattisgarh		37
7	Korba_UrjaNagar	Chhattisgarh		64
8	Kunjemura_OPJindalSchool	Chhattisgarh		28
9	Milupara_GovtHigherSecSchool	Chhattisgarh		23
10	Raipur_AIIMS	Chhattisgarh		45
11	Raipur_BhatagaonNewISBT	Chhattisgarh		44
12	Raipur_KrishakNagar	Chhattisgarh		32
13	Raipur_SiltaraPhaseII	Chhattisgarh		58
14	Tumidih_OPJindalIndustrialPark	Chhattisgarh		36
15	Bhopal_IdgahHills	Madhya Pradesh		44
16	Bhopal_ParyavaranParisar	Madhya Pradesh		80
17	Bhopal_TTNagar	Madhya Pradesh	74	68
18	Damoh_ShrivastavColony	Madhya Pradesh	59	36
19	Dewas_BhopalChauraha	Madhya Pradesh	49	49
20	Gwalior_CityCenter	Madhya Pradesh	98	112
21	Gwalior_DeenDayalNagar	Madhya Pradesh		116
22	Gwalior_MaharajBada	Madhya Pradesh		143
23	Gwalior_PhoolBagh	Madhya Pradesh	44	
24	Indore_ChhotiGwaltoli	Madhya Pradesh	68	37
25	Jabalpur_Marhatal	Madhya Pradesh	74	86
26	Katni_GoleBazar	Madhya Pradesh	88	90
27	Maihar_Sahilara	Madhya Pradesh	32	22
28	Mandideep_SectorD	Madhya Pradesh	61	55
29	Pithampur_Sector2	Madhya Pradesh	64	60
30	Ratlam_ShasthriNagar	Madhya Pradesh	47	52
31	Sagar_CivilLines	Madhya Pradesh		60
32	Sagar_DeenDayalNagar	Madhya Pradesh	44	18
33	Satna_BandhavgarColony	Madhya Pradesh	21	21
34	Singrauli_Vindhyachal	Madhya Pradesh	110	113
35	Ujjain_MahakaleshwarTemple	Madhya Pradesh	59	75

Note: October- February average is based on the mean of daily averages. All values are in µg/m^3. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB real-time data

Report 7

South Indian winter pollution: Overview of the air quality

Towards the end of winter season, the Urban Lab at the Centre for Science and Environment (CSE) has conducted an extensive analysis of the air quality trends in South India, with a specific focus on the states of Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Telangana and Puducherry. The objective has been to understand behaviour of the winter pollution in this region this October, 2022 to February, 2023. This also helps to locate the winter season within the longer term context of seasonal variation and annual trends in particulate pollution. This is part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on air quality.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019, 2020, 2021, 2022 and 2023. This analysis is based on the real time data available from the current working air quality monitoring stations in South India. A huge volume of data points have been cleaned and data gaps have been addressed based on the USEPA method for this analysis.

This analysis covers 96 continuous ambient air quality monitoring stations (CAAQMS) spread across 56 cities in two states: Andhra Pradesh -- two stations in Tirupati, two stations in Vijayawada, and one station each in Amaravati, Rajamahendravaram, Visakhapatnam, Anantapur, Chittoor and Kadapa; Kerala – three stations in Kochi, two stations in Thiruvananthapuram, and one station each in Kollam, Kannur, Kozhikode, and Thrissur; Karnataka -- twelve stations in Bengaluru, two stations each in Hubballi and Kalaburagi and one station each in Bagalkot, Bidar, Chamarajanagar, Chikkaballapur, Chikkamagaluru, Davanagere, Gadag, Hassan, Kolar, Koppal, Madikeri, Mangalore, Mysuru, Raichur, Ramanagara, Shivamogga, Udupi, Vijayapura, Yadgir, Belgaum, Dharwad, Haveri and Tumakuru; Tamil Nadu -- nine stations in Chennai, two stations in Coimbatore, and one station each in Gummidipoondi, Thoothukudi, Chengalpattu, Dindigul, Hosur, Kanchipuram, Ooty, Ramanathapuram, Salem, Tirupur, Vellore and Ariyalur; Telangana – fourteen stations in Hyderabad; Puducherry – one station at Pondicherry. The data is indicative of the current status of air quality and seasonal variation in particulate pollution in medium and smaller cities.

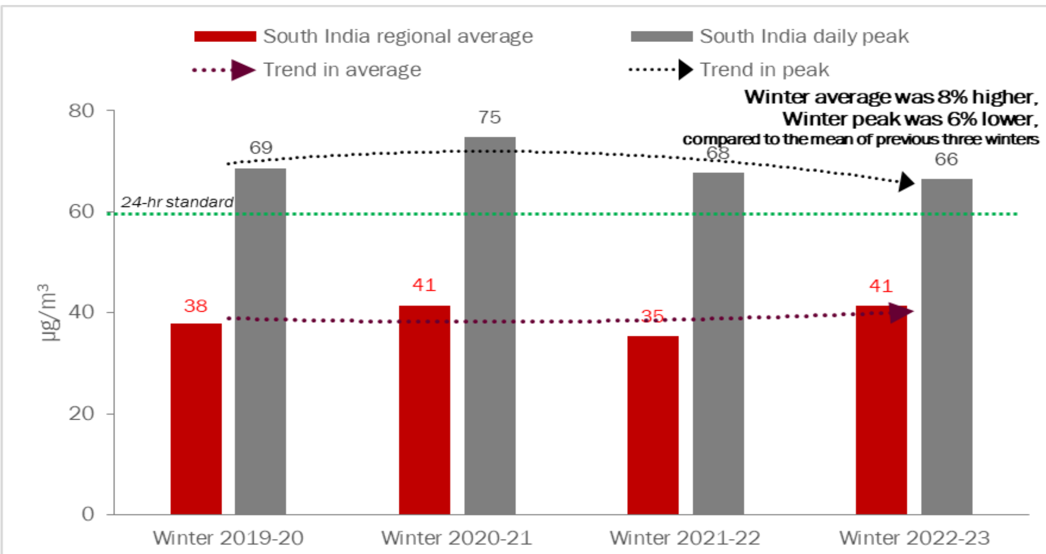
In many cities, the real time monitors have been set up recently and therefore long term data is not available. Several cities of the southern region have got their real time monitors in May 2022 and November 2022. Andhra Pradesh got 6 more real time stations, Bengaluru got 2 more stations, Tamil Nadu got 12 stations, Hyderabad got 8 stations, and Karnataka got 6 more real time monitoring stations.

The analysis shows that the regional pollution level in South India is low but rising. Expansion of the monitoring network into smaller cities has helped bring to light high pollution among these small cities and towns. Gummidipoondi, TN; Dharwad, KA; Tumakuru, KA and Kadapa, AP are most polluted cities in the region with pollution levels considerably higher than the Southern metropolises. Kerala shows the highest increase in its winter pollution while Karnataka the least. In Absolute terms Andhra Pradesh continues to be the most polluted state in the region.

Key findings: Regional

<u>This winter was the most polluted in last four years but peak pollution is down</u>: The winter average PM2.5 level across 23 cities of South India with functional CAAQMS stations since 2019 stood at 41 µg/m^3 this season (See *Graph 7R1: Trend in South India's winter PM2.5 levels*). PM2.5 level this winter has been 8 per cent higher compared to the mean of the previous three winters. Peak daily PM2/5 level this season happened on 5 December 2022 when the daily regional average stood at 66 µg/m^3. This seasonal peak was also the lowest of the last four winters. PM2.5 peak this winter has been 6 per cent lower compared to the mean of previous three winter peaks.

Graph 7R1: Trend in South India's winter PM2.5 levels

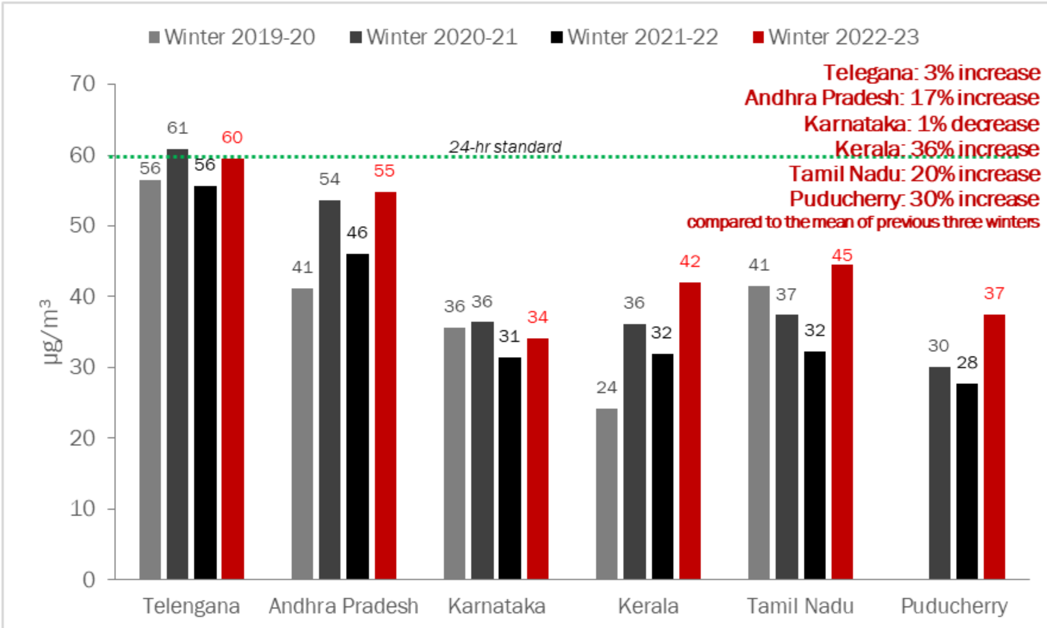


Note: 23 cities that constitute South India regional average Amaravati, Bagalkot, Bengaluru, Chamarajanagar, Chennai, Chikkaballapur, Chikkamagaluru, Coimbatore, Hubballi, Hyderabad, Kalaburagi, Kannur, Kochi, Kollam, Kozhikode, Mysuru, Rajamahendravaram, Ramanagara, Thiruvananthapuram, Tirupati, Vijaypura, Visakhapatnam and Yadgir. Winter is defined as 1 October-28 February. Winter average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data.

<u>All states of South India except Karnataka show rising winter pollution levels; Kerala worst performer with 36 per cent increase</u>: Winter pollution level in Kerala rose by 36 per cent compared to the mean of previous three winters, the highest among all states of South India. It is followed by Tamil Nadu with 20 per cent higher winter pollution level than the mean of previous three winters. Andhra Pradesh registered a 17 per cent increase, Telangana (only Hyderabad has real-time monitoring) shows 3 per cent higher PM2.5 level. (See *Graph 7R2: Trend in winter PM2.5 levels among states of South India*). Karnataka showed a marginal decrease of 1 per cent. Puducherry has only one station in Pondicherry which started functioning in 2020, therefore it is not possible to do a four year comparison as done with other states but it's this winter average is up by 30 per cent compared to the mean of the previous two winters.

In absolute concentration terms, Telangana (Hyderabad) with an average PM2.5 of 60 µg/m^3 was the most polluted state of South India. It was followed by Andhra Pradesh and Tamil Nadu with an average PM2.5 of 55 µg/m^3 and 45 µg/m^3 respectively. Kerala's regional average stood at 45 µg/m^3. Karnataka and Puducherry were the least polluted sub-region with average PM2.5 of 34 µg/m^3 and 37 µg/m^3 respectively.

Graph 7R2: Trend in winter PM2.5 levels among states of South India



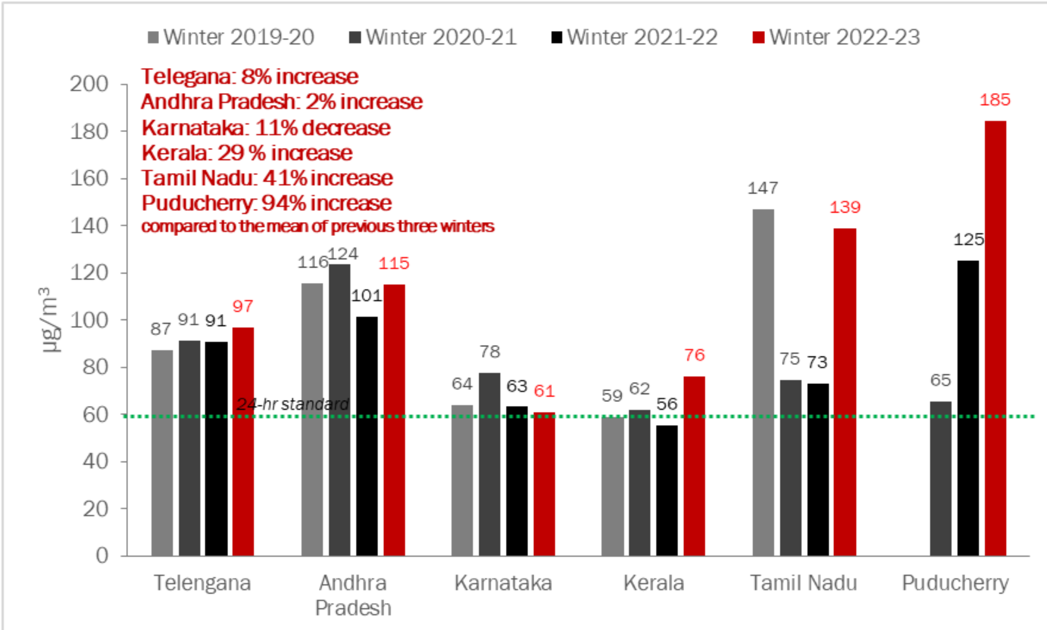
Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

Peak pollution also registered considerable spikes in all states of South India except Karnataka: Tamil Nadu with peak daily PM2.5 of 139 µg/m³ that was registered on 24 October (Diwali day) had the worst short-term pollution episodes among the states of South India. It is followed by Andhra Pradesh with peak daily PM2.5 of 115 µg/m³ on 6 December 2022. The peak for Telangana (Hyderabad on 23 February 2023) and Kerala (22 November 2022) stood at 97 µg/m³ and 76 µg/m³ respectively (See *Graph 7R3: Trend in winter PM2.5 peaks among the states of South India*). Karnataka had the lowest peak daily PM2.5 and it stood at 61 µg/m³ that was registered on 7 December 2022. Puducherry had a peak of 185 µg/m³ on Diwali day (24 October 2022) but given it is based on a single monitoring station it can be compared with the regional peak of other states which is based on multi-cities.

Winter peak in Tamil Nadu was 41 per cent higher than the mean of the previous three winter peaks. Similarly, peak for Kerala was 29 per cent higher, Telangana with 8 per cent higher and Andhra Pradesh with 2 per cent higher winter peak compared to the mean of previous three winter peaks. Karnataka recorded decline in peak level as its peak this winter is 11 per cent lower than the mean of previous three winters. Puducherry registered a 94 per cent increase in its peak this winter compared to the mean of previous two winter peaks.

Winter is problematic in South India as well: Air quality starts to deteriorate in late October across South Indian cities. The impact is more pronounced among cities located in Deccan Plateau and Eastern Ghats and marginal in Western Ghats. Industrial towns show the most number of days with poor AQI days (See *Graph 7R4: AQI calendar of PM2.5 level among South Indian cities).*

Graph 7R3: Trend in winter PM2.5 levels among states of South India



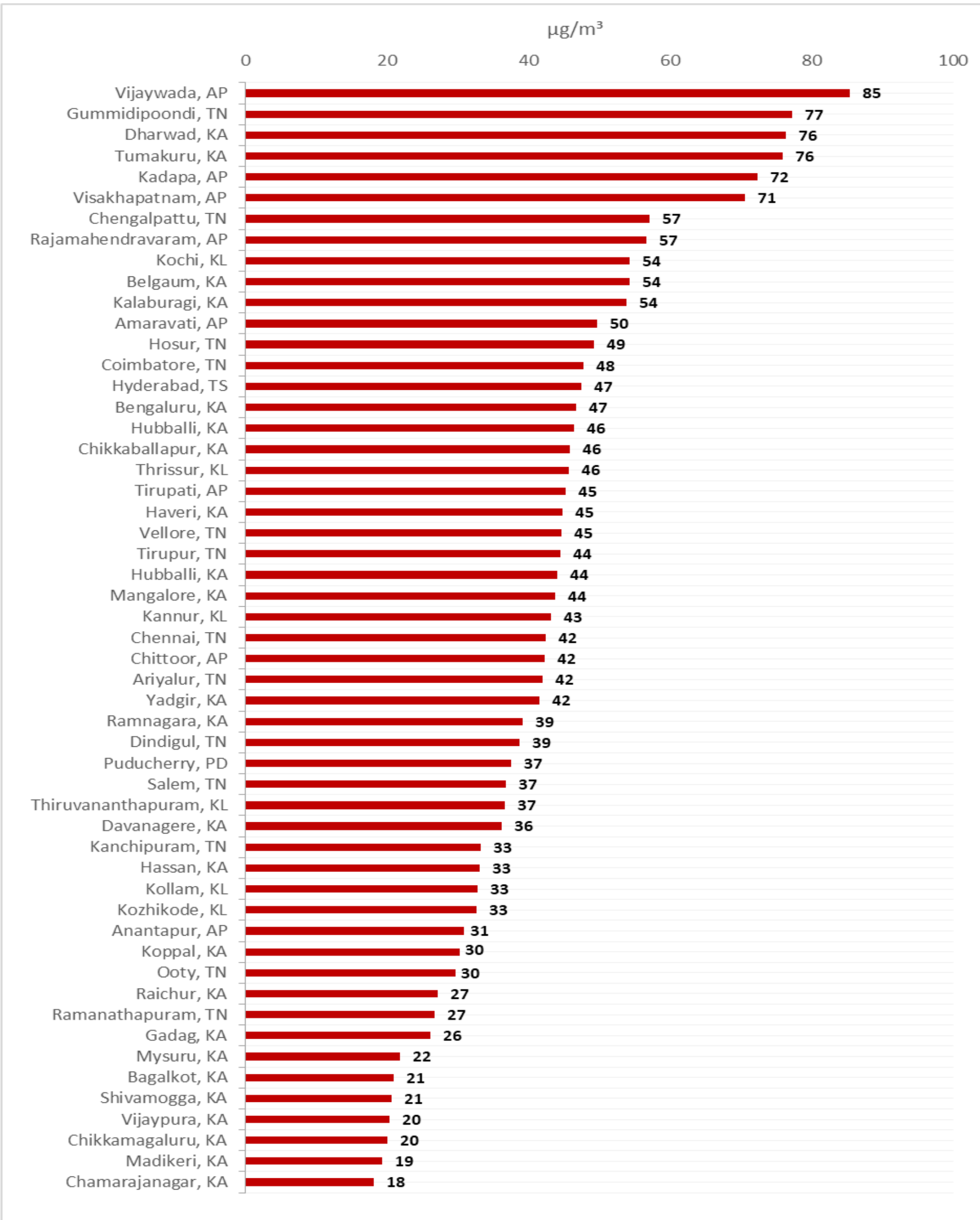
Note: Winter is defined as 1 October-28 February. Winter peak is based on the mean of daily averages of all cities in the states.
Source: CSE analysis of CPCB real-time data.

Graph 7R4: AQI calendar of PM2.5 level among South Indian cities

Note: Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB realtime data

<u>Vijayawada has the most polluted air in the region; smaller towns have dirtier air</u>: Vijayawada in Andhra Pradesh was the most polluted city in South India with average PM2.5 of 85 µg/m³ followed by Gummidipoondi in Tamil Nadu with 77 µg/m³ (See *Graph 7R5: Winter PM2.5 level among South Indian cities).* These are followed by Dharwad and Tumakuru in Karnataka with a winter average of 76 µg/m³ each. Kadapa and Visakhapatnam in Andhra Pradesh also registered winter levels that exceeded the 24-hr standard. Chamarajanagar and Madekeri in Karnataka were the least polluted cities with PM2.5 average of 18 µg/m³ and 19 µg/m³ respectively.

Graph 7R5: Winter PM2.5 level among South Indian cities

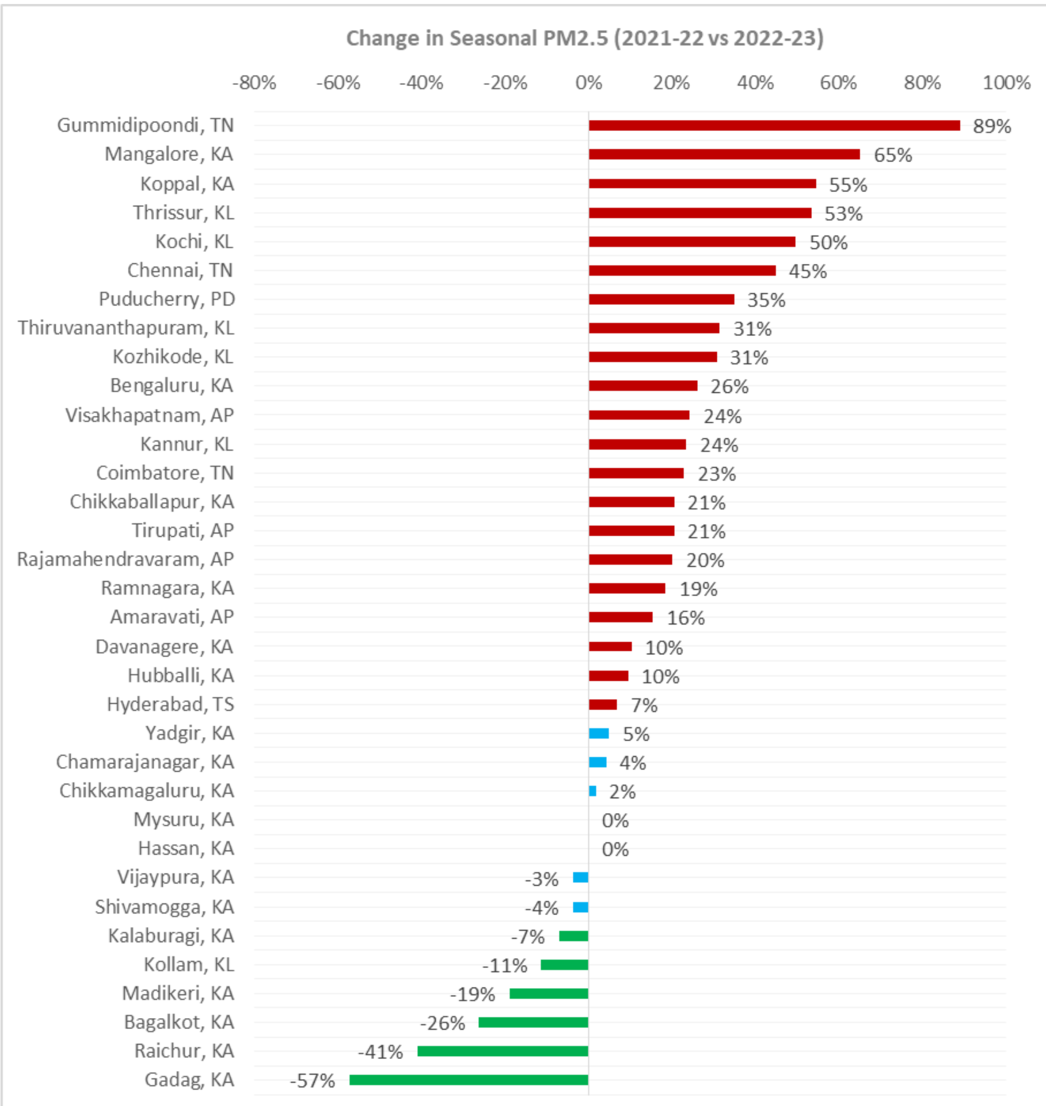


Note: Winter is defined as 1 October-28 February. Winter peak is based on the mean of daily averages. Cities with multiple stations are represented by the mean of all city stations.
Source: CSE analysis of CPCB real-time data

<u>Gummidipoondi and Mangalore registered the most increase in pollution this winter among South Indian cities</u>: Gadag in Karnataka have shown the most improvement in air quality this season compared to the same period previous year with 57 per cent. It is followed by Raichur with 41 per cent, Bagalkot with 26 per cent, Madikeri with 19 per cent and Kollam with 11 per cent lower PM2.5 compared to previous year. Mysuru shows no change in the seasonal PM2.5 level. (See *Graph 7R6: Change in winter PM2.5 level among South Indian cities 2021-22 vs 2022-23*).

Gummidipoondi in Tamil Nadu was the worst performer and registered an increase of 89 per cent from last year. It was followed by Mangalore and Koppal in Karnataka with an increase of 65 per cent and 55 per cent respectively. Kerala has most cities among top 10 worst performers. These are Thrissur (53 per cent), Kochi (50 per cent), Thiruvananthapuram (31 per cent) and Kozhikode (31 per cent),

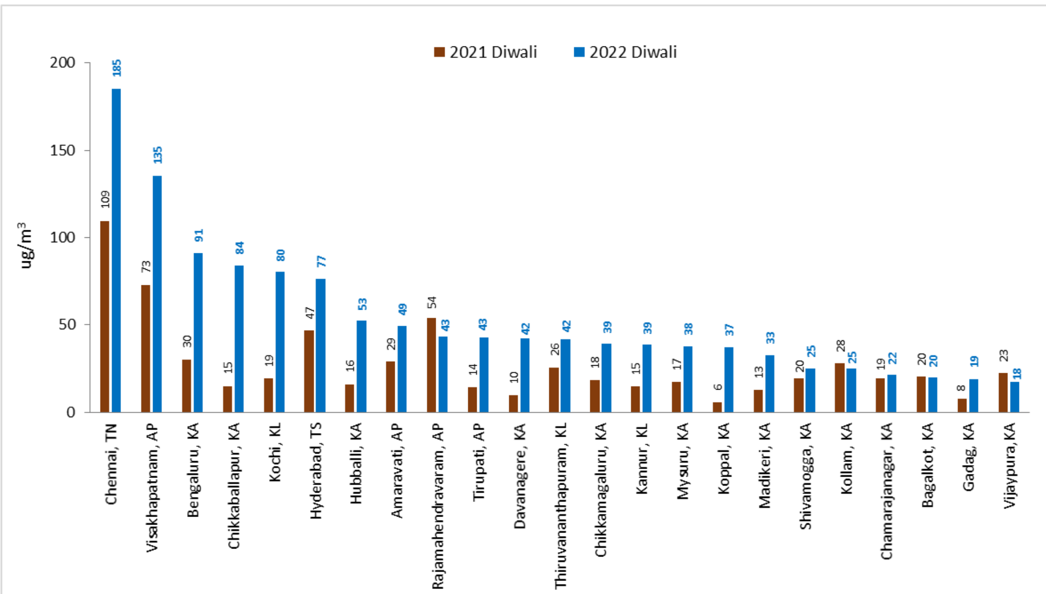
Graph 7R6: Change in winter PM2.5 level among South Indian cities 2021-22 vs 2022-23



Note: 1 October-28 February 2021-22 and 2022-23 average is based on mean of daily averages. Cities with multiple stations are represented by the mean of all city stations. Cities with data in both 2021 and 2022 are compared.
Source: CSE analysis of CPCB real-time data

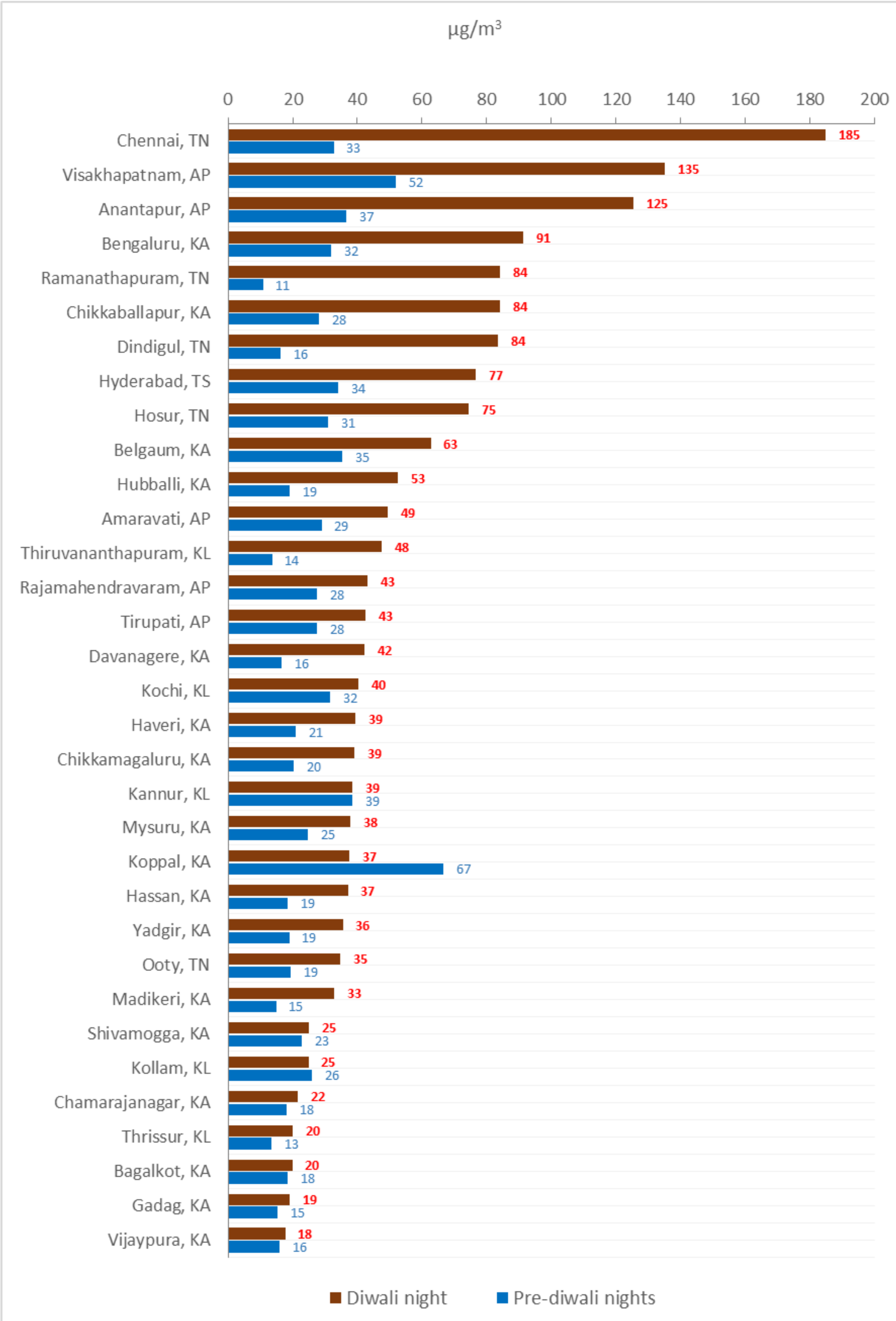
<u>Ramanathapuram and Chennai saw the greatest jump in its Diwali pollution cities of South Indian cities</u>: Pollution level on Diwali night (8pm to 8am) in cities shot up by 0.6 – 7.8 times the average level recorded seven nights preceding Diwali (See *Graph 7R7: Diwali night pollution among cities of South India*). Ramanathapuram in Tamil Nadu saw the greatest jump of 7.8 time's higher PM2.5 level on Diwali night at 84 µg/m^3. However, Chennai saw a jump of 5.6 time's higher PM2.5 concentration but its pollution level is greatest among the South Indian region at 185 µg/m^3. Vijaypura, KA and Gadag, KA had the least polluted Diwali night in the region each with 18 µg/m^3 and 19 µg/m^3. This Diwali is more polluted compared to last year's Diwali for all major cities in the region. Chennai had seen the maximum increase on Diwali night compared to 2021 Diwali followed by Visakhapatnam and Bengaluru (See *Graph 7R8: Trend in Diwali night pollution among major cities of South India*).

Graph 7R8: Trend in Diwali night pollution among major cities of South India



Note: PM2.5 values for cities with more than one monitoring station is based on average of all stations that have continuous and adequate data for complete assessment period. Diwali night is considered from 8.00PM to 8.00AM on 4 November 2021 and 24 October 2022.
Source: CSE analysis of real-time data from CPCB portal.

Graph 7R7: Diwali night pollution among cities of South India



Note: PM2.5 values for cities with more than one monitoring station is based on average of all stations that have continuous and adequate data for complete assessment period. Diwali night is considered from 8.00PM October 24 to 8.00AM October 25. Pre-diwali night is an average of seven nights (8.00PM-8.00AM) preceding Diwali.
Source: CSE analysis of real-time data from CPCB portal

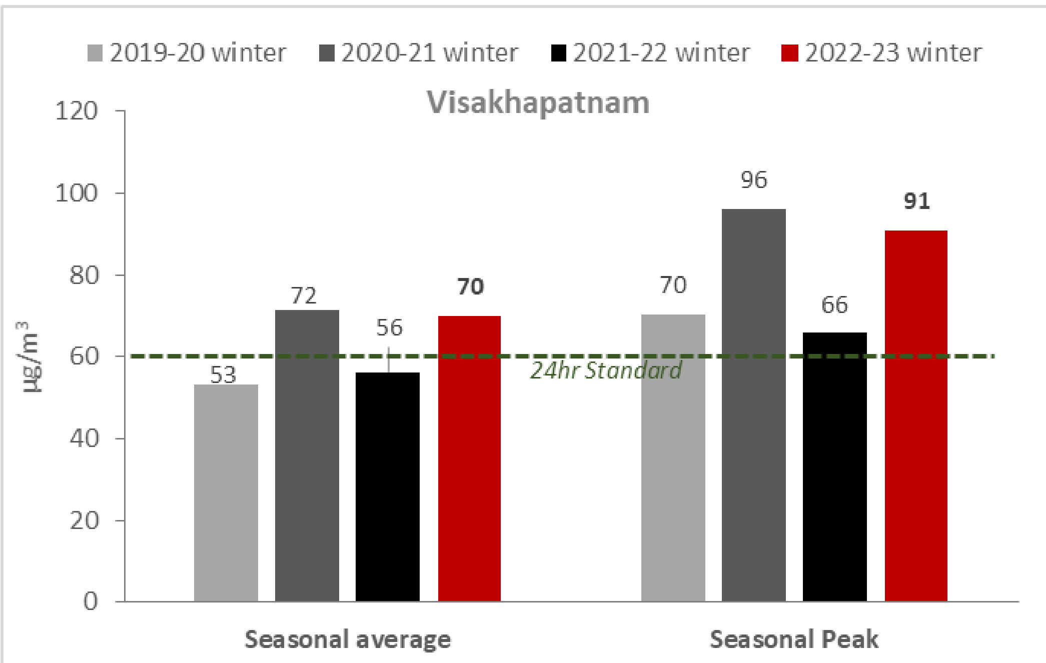
Key findings: Cities

Note: This does not include Bengaluru, Hyderabad and Chennai as they have been covered in the mega-cities analysis under Report 2.

Andhra Pradesh: Visakhapatnam

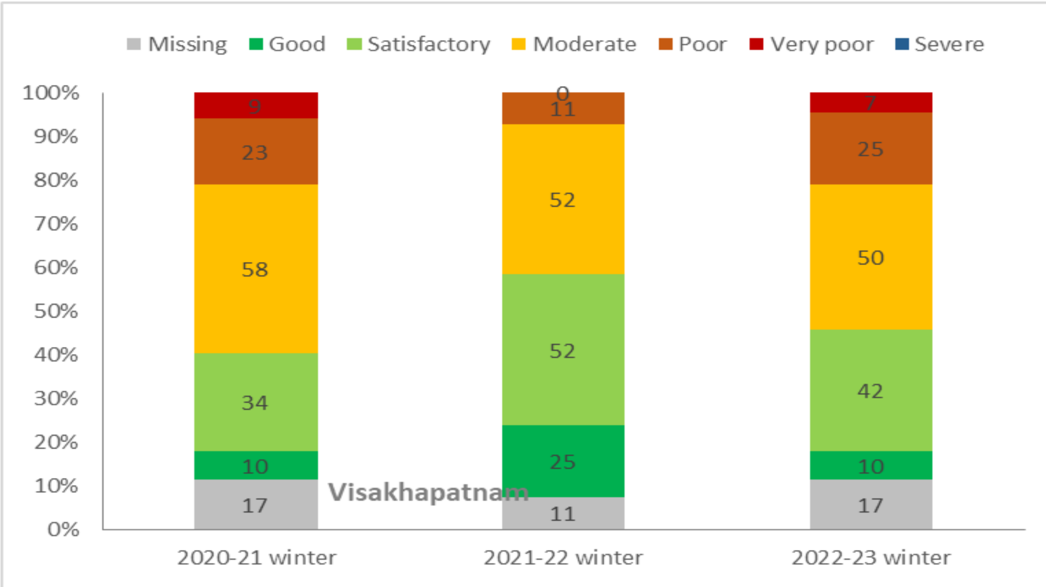
Winter pollution level in Visakhapatnam this season has been 16 per cent higher than the mean of previous three winters and is considerably higher than the standard (See *Graph 7R9: PM2.5 winter trend in Visakhapatnam*). Similarly, the seasonal peak is also increasing this winter. There has been a 17 per cent rise in winter peak compared to the mean of peaks of the previous three winters. AQI categorization of day's shows that the city's air quality has not deteriorated to severe days in the last three years. Also the city has recorded 7 very poor days and the number of days with poor air quality has also increased this winter compared to the last two winters. (See *Graph 7R10: PM2.5 AQI trend in Visakhapatnam*).

Graph 7R9: PM2.5 winter trend in Visakhapatnam



Note: PM2.5 values are based on stations that have continuous and adequate data. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 7R10: PM2.5 AQI trend in Visakhapatnam

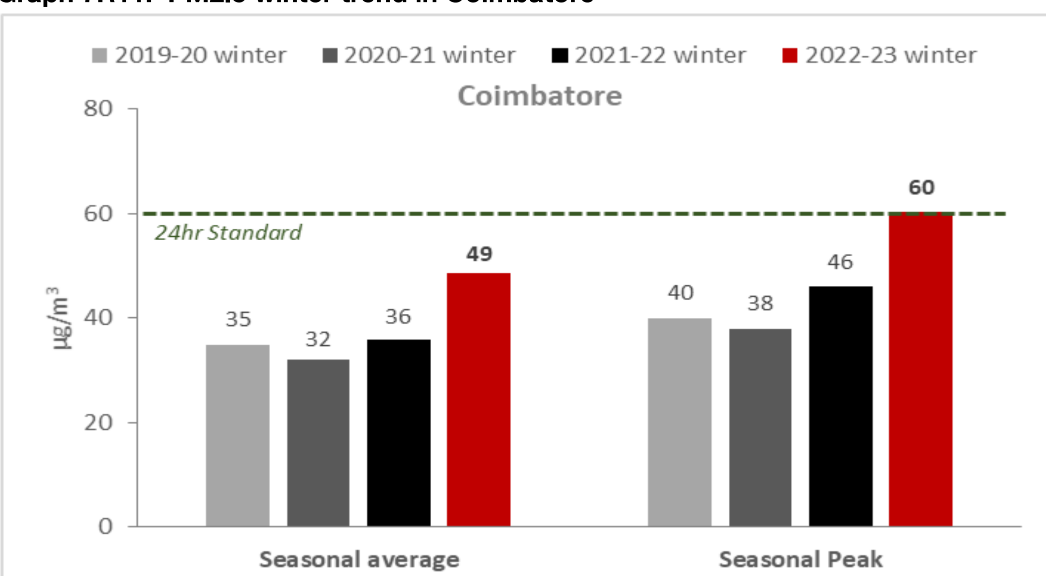


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Tamil Nadu: Coimbatore

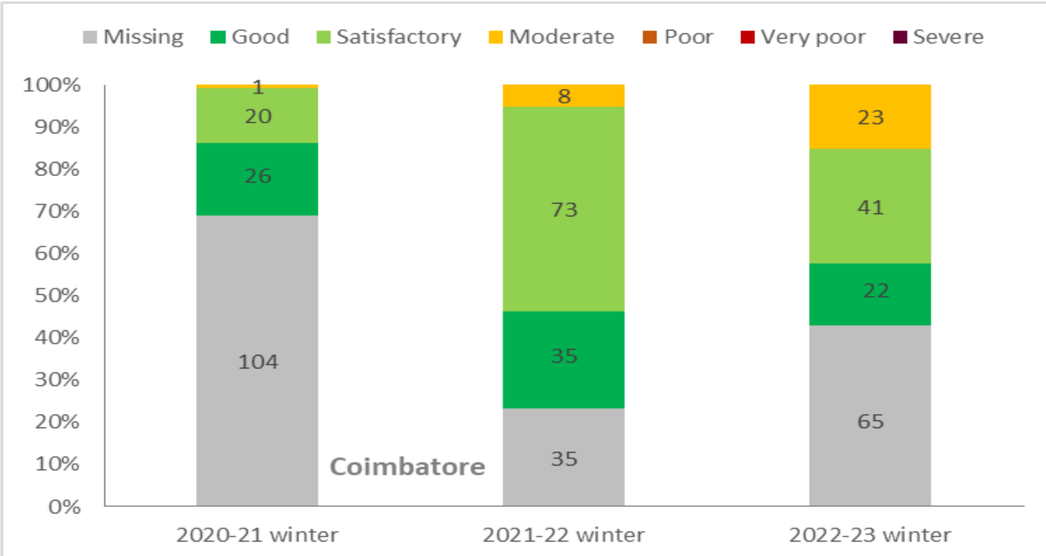
Winter pollution level in Coimbatore this season has been 42 per cent higher than the mean of previous three winters but it is lower than the standard. Also there has been a 46 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 7R11: PM2.5 winter trend in Coimbatore*). AQI categorization shows that the city's air quality has not deteriorated to severe days in the last three years but the number of days with good and satisfactory air quality has decreased going from 108 to 63 days compared to last winter (See *Graph 7R12: PM2.5 AQI trend in Coimbatore*).

Graph 7R11: PM2.5 winter trend in Coimbatore



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 7R12: PM2.5 AQI trend in Coimbatore

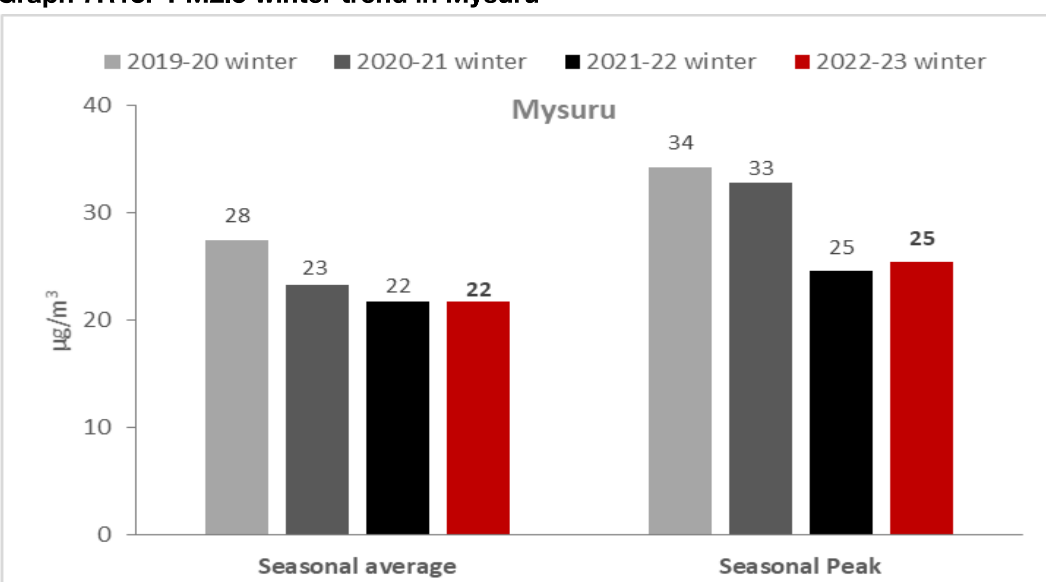


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Karnataka: Mysuru

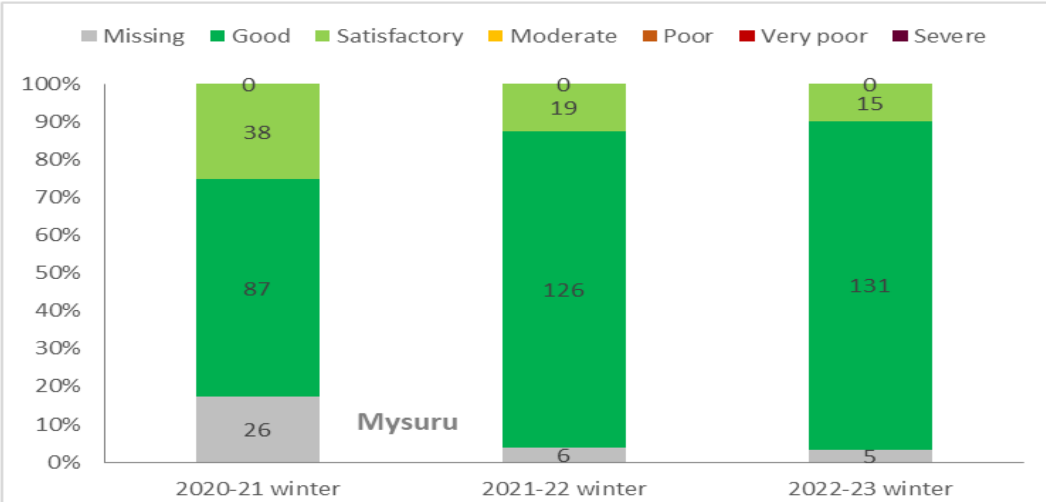
Winter pollution level in Mysuru has been stable for the last three years but this season there has been a 10 per cent decline in the seasonal average compared to the mean of previous three winters. Also, there has been a decline in winter peak with 17 per cent compared to the mean of peaks of the previous three winters. (See *Graph 7R13: PM2.5 winter trend in Mysuru*). AQI categorization shows that the city's air quality has not deteriorated to severe days or bad days from the last three years. Also there is an increase in the number of good days this winter compared to the previous two winters. (See *Graph 7R14: PM2.5 AQI trend in Mysuru*).

Graph 7R13: PM2.5 winter trend in Mysuru



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 7R14: PM2.5 AQI trend in Mysuru

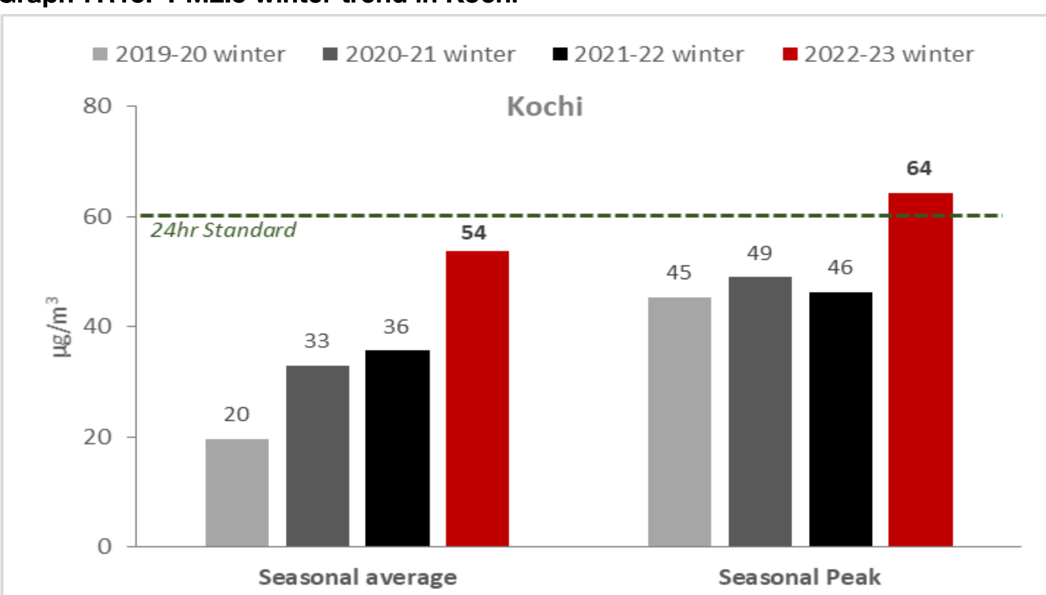


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Kerala: Kochi

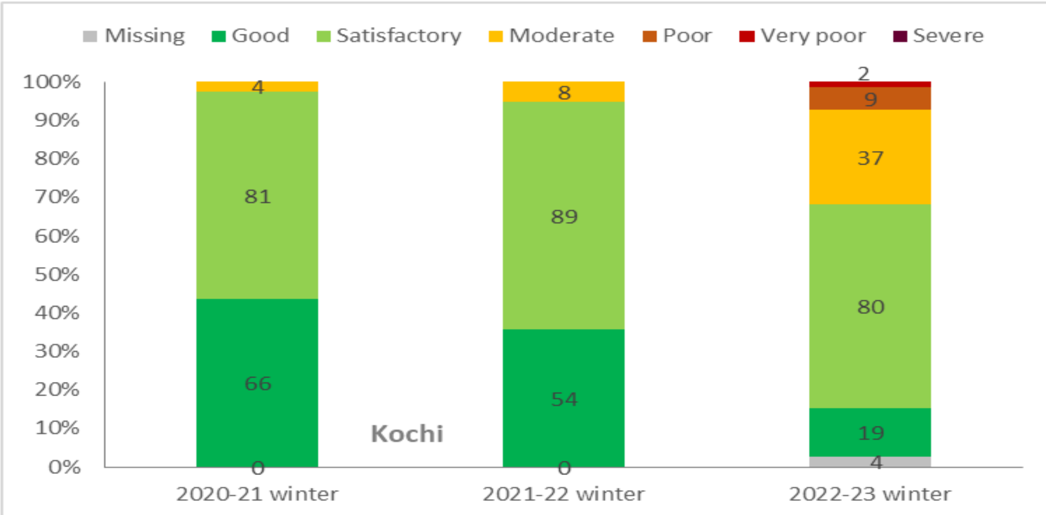
Winter pollution level in Kochi this season has been 83 per cent higher than the mean of previous three winters and with a seasonal average of 54 µg/m^3 the city's air quality is considerably higher than the last three winters. Similarly, there has been a 37 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 7R15: PM2.5 winter trend in Kochi)*. AQI categorization shows that the city's air quality has not deteriorated to severe air quality and had 11 days of very poor and poor air quality, a considerable increase compared to previous two winters when it has recorded no bad days. (See *Graph 7R16: PM2.5 AQI trend in Kochi*). Also, the number of good days are declining this winter going from 54 to just 19 good days.

Graph 7R15: PM2.5 winter trend in Kochi



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 7R16: PM2.5 AQI trend in Kochi

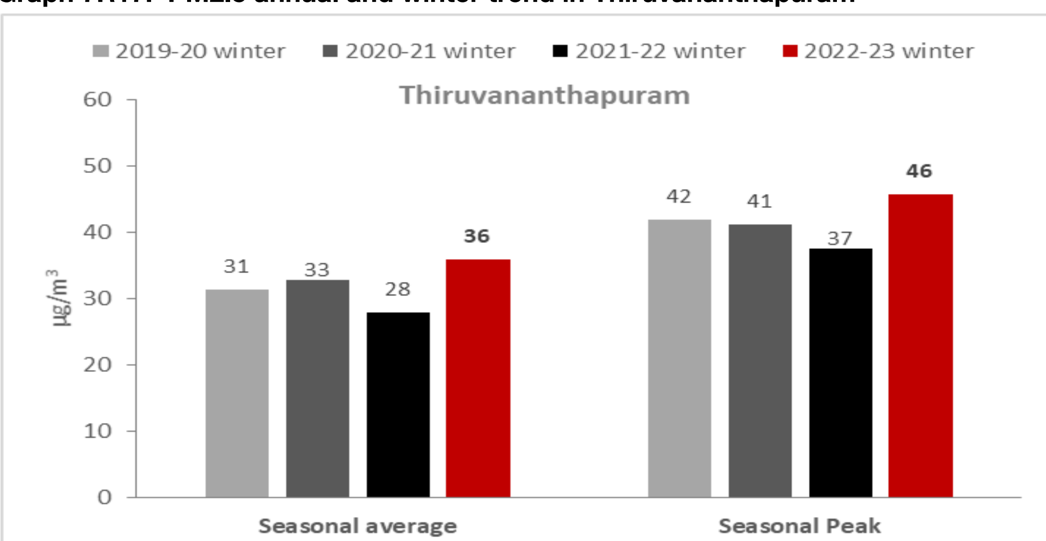


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Kerala: Thiruvananthapuram

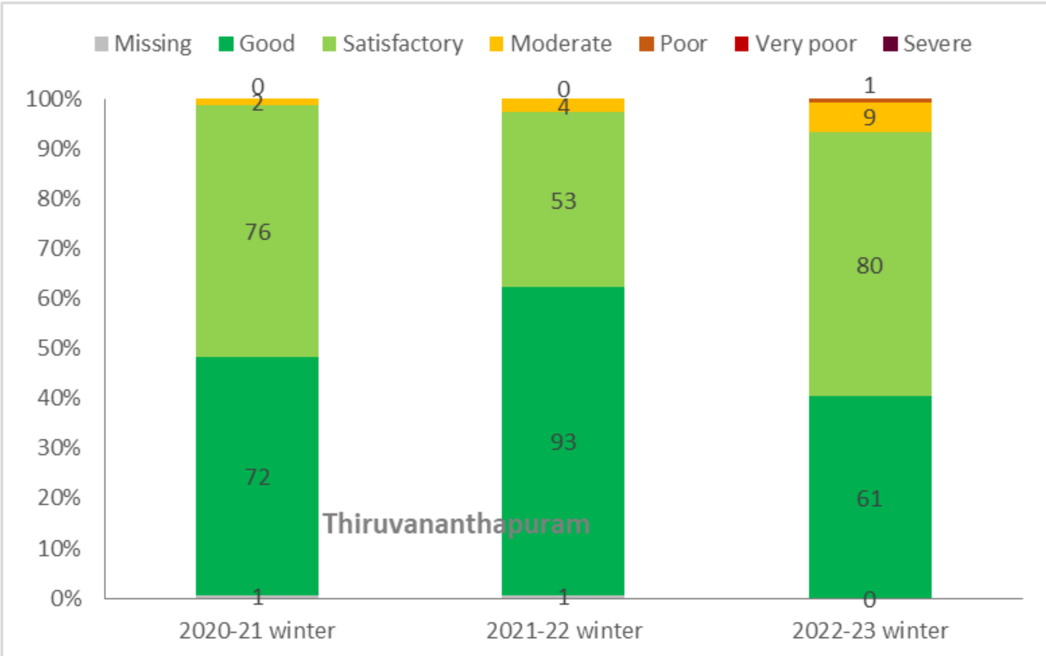
Winter pollution level in Thiruvananthapuram this season has been 17 per cent higher than the mean of previous three winters and with seasonal average of 36 µg/m³ the city's air quality is considerably higher than the last three winters but still lower than the standard. Similarly, there has been a 14 per cent increase in winter peak compared to the mean of peaks of the previous three winters (See *Graph 7R17: PM2.5 winter trend in Thiruvananthapuram).* AQI categorization shows that the city's air quality has deteriorated with 1 poor day this winter. Also, the city has recorded 61 days of good air quality, a considerable decrease compared to previous two winters (See *Graph 7R18: PM2.5 AQI trend in Thiruvananthapuram).* There were 93 "good" days in the 2021-22 winter and 72 "good" days in the 2020-21 winter.

Graph 7R17: PM2.5 annual and winter trend in Thiruvananthapuram



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 7R18: PM2.5 AQI trend in Thiruvananthapuram



Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Annexure 7R

Winter PM2.5 level at station levels among South Indian cities

	Station	State	2021-22 winter	2022-23 winter
1	Kochi_Vyttila	Kerala	43	87
2	Hyderabad_ZooPark	Telangana	64	71
3	Chennai_Alandur	Tamil Nadu	29	70
4	Visakhapatnam_GVMC	Andhra Pradesh	56	70
5	Hyderabad_Sanathnagar	Telangana	62	68
6	Gummidipoondi_APNagar	Tamil Nadu	38	65
7	Bengaluru_BapujiNagar	Karnataka	55	65
8	Hyderabad_IDAPashamylaram	Telangana	57	62
9	Bengaluru_Jayanagar	Karnataka	43	62
10	Hyderabad_ICRISAT	Telangana	53	59
11	Hyderabad_Bollaram	Telangana	54	59
12	Rajamahendravaram_AnandKalaKshetram	Andhra Pradesh	47	55
13	Belgaum_RamteerthNagar	Karnataka		55
14	Kalaburagi_LalBahadurShastriNagar	Karnataka	58	54
15	Chengalpattu_CrescentUniversity	Tamil Nadu		51
16	Vellore_Vasanthapuram	Tamil Nadu		50
17	Kozhikode_Palayam	Kerala	25	49
18	Amaravati_Secretariat	Andhra Pradesh	43	49
19	Hosur_SIPCOTPhase	Tamil Nadu		49
20	Coimbatore_SIDCO	Tamil Nadu	36	49
21	Hubballi_DeshpandeNagar	Karnataka	42	47
22	Chennai_GandhiNagar_Ennore	Tamil Nadu		47
23	Hyderabad_Somajiguda	Telangana		46
24	Chikkaballapur_Rural	Karnataka	38	46
25	Haveri_AshwiniNagar	Karnataka		46
26	Bengaluru_SilkBoard	Karnataka	35	46
27	Tirupur_KumaranCollege	Tamil Nadu		45
28	Tirupati_Tirumala	Andhra Pradesh	37	45
29	Chennai_Royapuram	Tamil Nadu	29	44
30	Bengaluru_Hebbal	Karnataka	36	44
31	Chennai_Perungudi	Tamil Nadu	31	44
32	Kannur_Thavakkara	Kerala	34	44
33	Hyderabad_CentralUniversity	Telangana	44	43
34	Mangalore_Kadri	Karnataka	27	43
35	Thrissur_CorporationGround	Kerala	28	43
36	Chennai_Arumbakkam	Tamil Nadu	38	42
37	Yadgir_CollectorOffice	Karnataka	39	42
38	Chennai_Manali	Tamil Nadu	25	42
39	Bengaluru_BTMLayout	Karnataka	37	41
40	Davanagere_Devaraj	Karnataka	33	39
41	Ramnagara_VijayNagar	Karnataka	33	39
42	Dindigul_MendonsaColony	Tamil Nadu		39
43	Bengaluru_Peenya	Karnataka	38	39

	Station	State	2021-22 winter	2022-23 winter
44	Hyderabad_NacharamTSIICIALA	Telangana		38
45	Hyderabad_Kokapet	Telangana		38
46	Hyderabad_Ramachandrapuram	Telangana		38
47	Puducherry	Puducherry	27	37
48	Thiruvananthapuram_Kariavattom	Kerala	31	37
49	Hyderabad_NewMalakpet	Telangana		37
50	Hyderabad_IITHKandi	Telangana		37
51	Salem_SonaCollege	Tamil Nadu		36
52	Thiruvananthapuram_Plammoodu	Kerala	25	36
53	Hassan_B_Katihalli	Karnataka	32	36
54	Hyderabad_KompallyMunicipalOffice	Telangana		33
55	Kollam_Polayathode	Kerala	37	33
56	Chennai_Velachery	Tamil Nadu	18	32
57	Eloor_Udyogamandal	Kerala	32	32
58	Kanchipuram_Kilambi	Tamil Nadu		31
59	Bengaluru_HombegowdaNagar	Karnataka	32	31
60	Anantapur_Gulzarpet	Andhra Pradesh		31
61	Koppal_DiwatorNagar	Karnataka	19	31
62	Hyderabad_ECILKapra	Telangana		30
63	Ooty_BombayCastel	Tamil Nadu		30
64	Ramanathapuram_ChalaiBazaar	Tamil Nadu		26
65	Gadag_PanchalNagar	Karnataka	64	26
66	Raichur_HajiColony	Karnataka	46	26
67	Mysuru_Hebbal1stStage	Karnataka	22	22
68	Chennai_Kodungaiyur	Tamil Nadu	34	21
69	Bagalkot_Vidayagiri	Karnataka	28	21
70	Shivamogga_VinobaNagara	Karnataka	21	21
71	Chikkamagaluru_KalyanaNagara	Karnataka	20	20
72	Vijaypura_Ibrahimpur	Karnataka	21	20
73	Madikeri_StuartHill	Karnataka	23	19
74	Chamarajanagar_Urban	Karnataka	17	18
75	Bengaluru_BWSSB	Karnataka	31	
76	Kolar_Tamaka	Karnataka	36	

Note: October- February average is based on the mean of daily averages. All values are in µg/m^3. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB real-time data

Report 8

Northeast Indian winter pollution: Overview of the air quality

Towards the end of winter season, the Urban Lab at the Centre for Science and Environment (CSE) has conducted an extensive analysis of the air quality trends in Northeast India. The objective has been to understand the behaviour of the winter pollution in this region. This also helps to locate the winter season within the longer-term context of seasonal variation and annual trends in particulate pollution. This is part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on air quality.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 28 February from 2019 to 2023. This analysis is based on the real time data available from the current working air quality monitoring stations in Northeast India. A huge volume of data has been cleaned and data gaps have been addressed based on the USEPA method for this analysis.

This regional analysis covers 19 continuous ambient air quality monitoring stations (CAAQMS) spread across 13 cities in eight states: Assam – four stations in Guwahati, and one station each in Sivasagar, Byrnihat, Nalbari, Silchar, and Nagaon; Meghalaya – two stations in Shillong; Tripura – two stations in Agartala; Manipur – two stations in Imphal; Mizoram – one station in Aizawl; Nagaland – one station in Kohima; Arunachal Pradesh – one station in Naharlagun and Sikkim – one station in Gangtok. The data is only indicative of the status of air quality and seasonal variation in particulate pollution in medium and smaller cities due to limited monitoring and complex hill terrain in most of the cities of Northeast India.

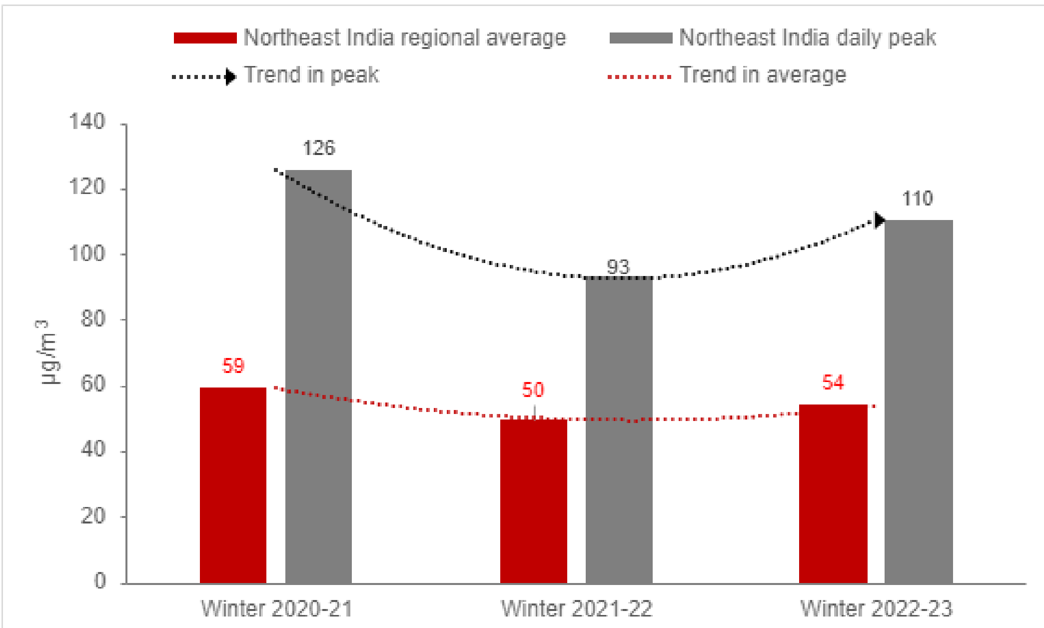
In many cities, the real time monitors have been set up recently and therefore long-term data is not available. Several cities of Northeast region have got their real time monitors during April-September of 2022. Assam got 7 real time stations; Manipur got 2 real time stations; Meghalaya, Tripura and Sikkim each got one more real time stations during this period.

The analysis shows that the regional pollution level in Northeast India has rebound this winter after registering a marginal improvement in the previous winter. Daily peak pollution is rising across all cities of Northeast. Assam cities are the most polluted in the region followed by cities of Tripura. Even though pollution levels are low among the hilly towns like Aizawl and Shillong, they are showing an increasing trend over the past few winters.

Key findings: Regional

<u>This winter pollution made a rebound after improvement noted in winter of 2021-22</u>: The average PM2.5 level across cities of Northeast India with functional CAAQMS stations stood at 54 µg/m^3 this winter (See *Graph 8R1: Trend in Northeast India´s winter PM2.5 levels*). PM2.5 level this winter has been 9 per cent higher compared to the previous winter. Daily peak this season happened on 21 February when the daily regional average stood at 110 µg/m^3. This seasonal peak was 18 per cent higher compared to the previous winter peak.

Graph 8R1: Trend in Northeast India´s winter PM2.5 levels

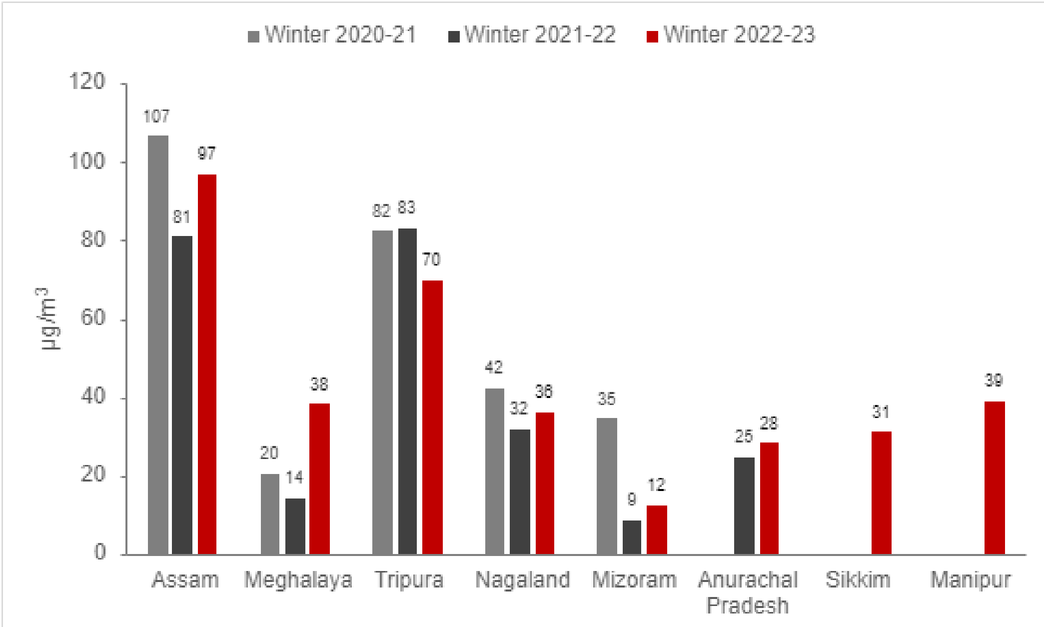


Note: Northeast India regional average is based on five cities: Guwahati, Shillong, Agartala, Aizawl and Kohima. Winter is defined as 1 October-28 February. Winter average is based on mean of daily averages where continuous data is available since 2020.
Source: CSE analysis of CPCB real-time data.

<u>All states of Northeast India except Tripura show a jump in winter pollution this past winter compared to the previous winter</u>: Winter pollution level in Meghalaya was 170 per cent higher compared to the previous winter, the highest among all states of Northeast India. Mizoram was the second worst performer with 46 per cent jump in winter levels. Assam´s winter pollution was 19 per cent higher compared to the previous winter. Nagaland and Anurachal Pradesh registered 13 per cent and 14 per cent higher than the previous winter respectively. Tripura bucked the regional trend and registered a 16 per cent fall in winter pollution level compared to previous winter (See *Graph 8R2: Trend in winter PM2.5 levels among the states of Northeast India*). Sikkim and Manipur got their real time monitoring station this past winter only, therefore tread could not be established for them.

In absolute concentration terms, Assam with an average PM2.5 of 97 µg/m^3 was the most polluted state of Northeast India. It was followed by Tripura with a winter average of 70 µg/m^3. Manipur, Meghalaya and Nagaland recorded similar winter averages of 39 µg/m^3, 38 µg/m^3 and 36 µg/m^3 respectively. Sikkim and Anurachal Pradesh registered a winter average of 31 µg/m^3 and 28 µg/m^3 respectively. Mizoram was the least polluted state with a winter average of 12 µg/m^3.

Graph 8R2: Trend in winter PM2.5 levels among states of Northeast India

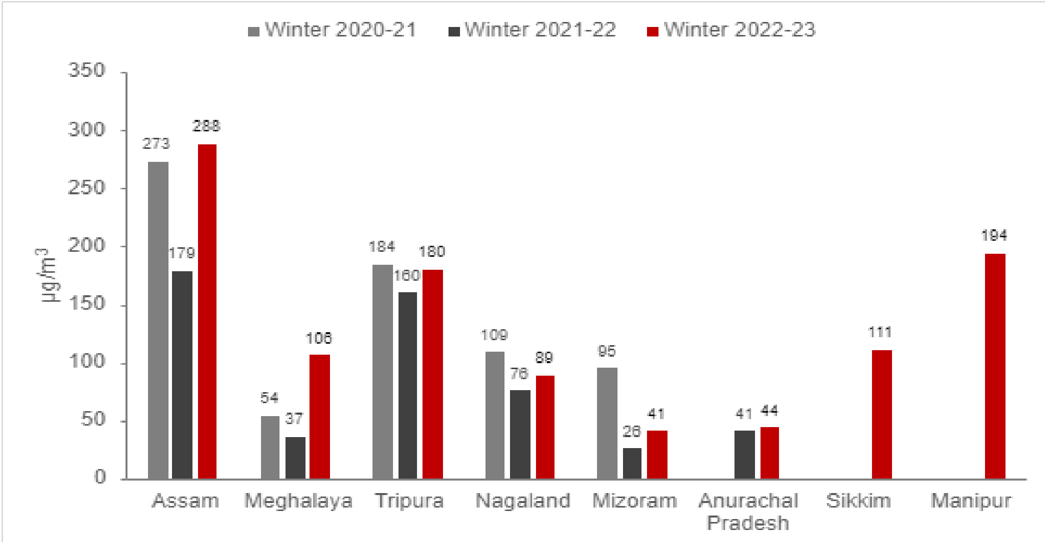


Note: State levels are based on a single city due to lack of monitoring in these states. These cities are Assam: Guwahati, Meghalaya: Shillong, Tripura: Agartala, Mizoram: Aizawl, Nagaland: Kohima, Arunachal Pradesh: Naharlagun, Sikkim: Gangtok, and Manipur: Imphal. Winter is defined as 1 October-28 February. Winter average is based on mean of daily averages where continuous data is available since 2020.
Source: CSE analysis of CPCB real-time data

Peak pollution is worst in Assam and peaks are rising across all states of Northeast India: Assam registered a peak PM2.5 of 288 µg/m^3 which was the worst peak among all the states of Northeast India. Manipur recorded the second highest peak and it stood at 194 µg/m^3, despite having one of the lowest seasonal averages in the region. It is followed by Tripura, Sikkim and Meghalaya with peaks of 180 µg/m^3, 111µg/m^3 and 106 µg/m^3 respectively (See *Graph 8R3: Trend in winter PM2.5 peaks among the states of Northeast India*). Nagaland registered a peak of 89 µg/m^3. The lowest peaks were recorded in Mizoram and Arunachal Pradesh where daily levels never crossed 41 µg/m^3 and 44 µg/m^3 respectively. Winter peak in Meghalaya was 191 per cent higher compared to the previous winter peak. Assam and Mizoram registered 161 per cent and 160 per cent higher peaks this winter compared to previous winter peaks respectively. was 19 per cent higher than the mean of the previous three winter peaks. Similarly, peaks for Nagaland, Tripura and Mizoram were 17 per cent, 13 per cent and 7 per cent higher.

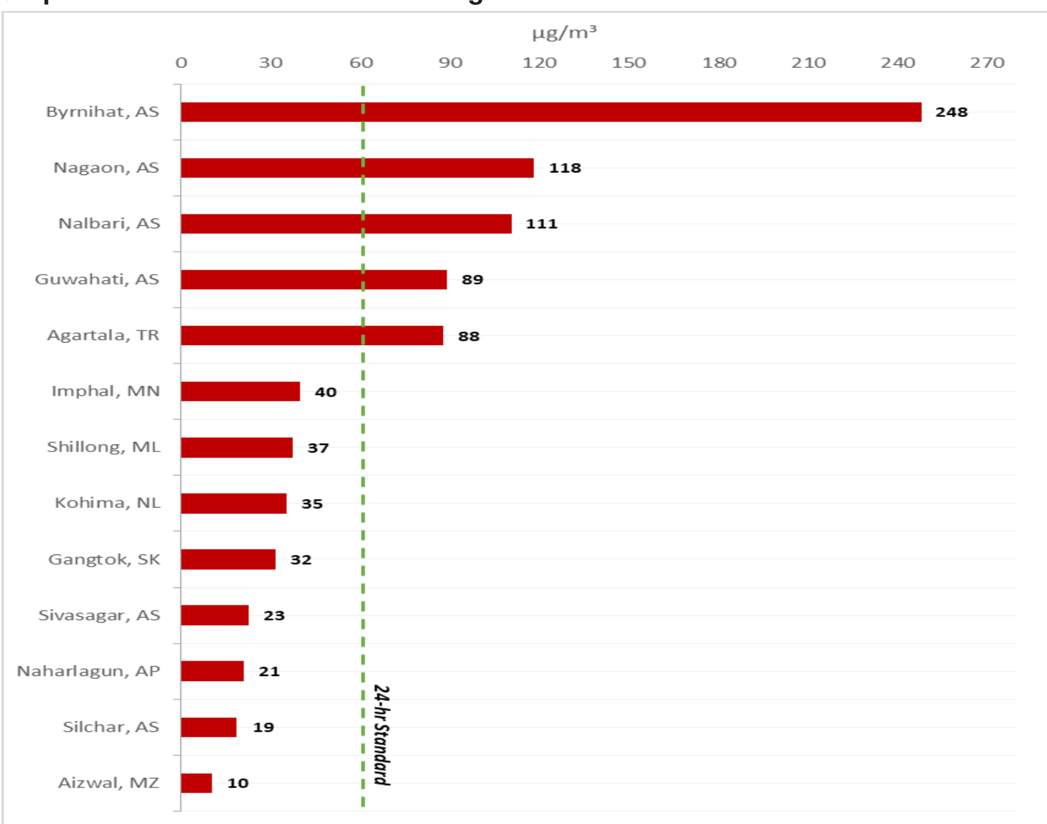
Cities of Assam have the most polluted air in the region: Byrnihat in Assam was the most polluted city in Northeast India with average PM2.5 of 248 µg/m^3 followed by Nagaon in Assam with 118 µg/m^3. Cities of Assam occupy top four spots on the list of most polluted cities in Northeast India. Agartala in Tripura is ranked fifth with an average PM2.5 of 88 µg/m^3 (See *Graph 8R4: Winter PM2.5 level among Northeast Indian cities).* All other cities have registered pollution levels below the standard limit. Aizawl in Mizoram was the least polluted city with an average PM2.5 of 10 µg/m^3.

Graph 8R3: Trend in winter PM2.5 peaks among states of Northeast India



Note: State levels are based on a single city due to lack of monitoring in these states. These cities are Assam: Guwahati, Meghalaya: Shillong, Tripura: Agartala, Mizoram: Aizawl, Nagaland: Kohima, Arunachal Pradesh: Naharlagun, Sikkim: Gangtok, and Manipur: Imphal. Winter is defined as 1 October-28 February. Winter peak is based on the mean of daily averages of all cities.
Source: CSE analysis of CPCB real-time data.

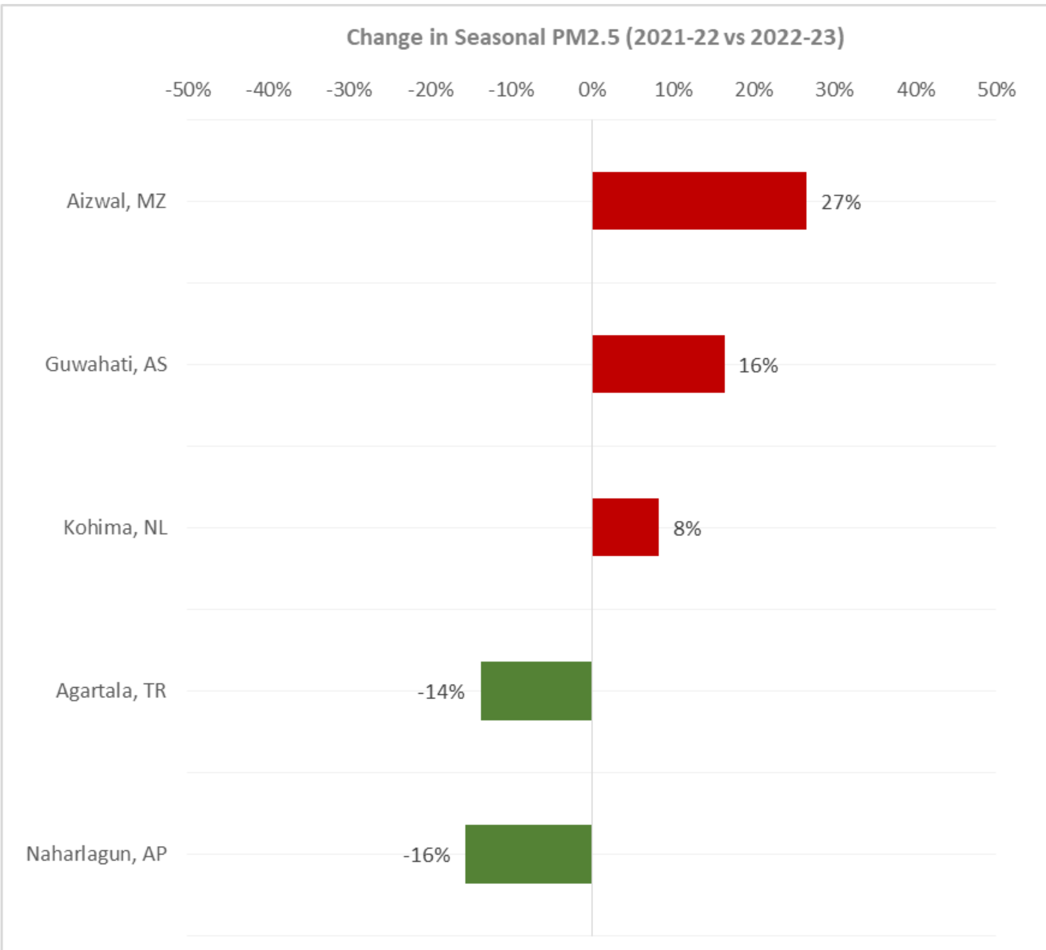
Graph 8R4: Winter PM2.5 level among Northeast Indian cities



Note: Winter is defined as 1 October-28 February. Winter average is based on the mean of daily averages. Cities with multiple stations are represented by the mean of all city stations.
Source: CSE analysis of CPCB real-time data

Aizawl registered the most increase in pollution this winter among Northeast Indian cities: Despite being the least polluted cities in the region Aizawl was the worst performer as far as trend in winter air quality goes since it registered an increase of 27 per cent in winter PM2.5 level compared to previous winter. A rising trend was noted in Guwahati, AS and Kohima, NL as well with an increase of 16 per cent and 8 per cent respectively. Nahrlagun in Arunachal Pradesh has shown the most improvement in air quality this season compared to the same period previous year with 27 per cent. Agartala also registered a 14 per cent improvement in PM2.5 compared to previous winter (See *Graph 8R5: Winter PM2.5 change among Northeast Indian cities 2021-22 vs 2022-23*).

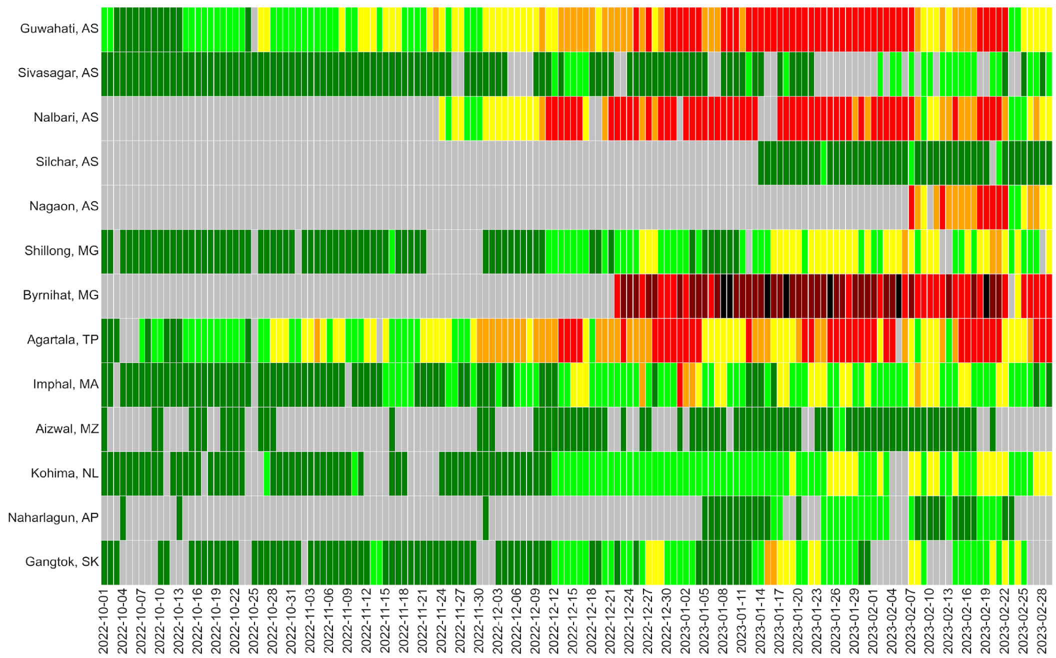
Graph 8R5: Winter PM2.5 change among Northeast Indian cities 202-22 vs 2022-23



Note: Winter is defined as 1 October-28 February. Winter average is based on the mean of daily averages. Cities with multiple stations are represented by the mean of all city stations.
Source: CSE analysis of CPCB real-time data

Winter is problematic for all cities of Northeast but there is no clear regional pattern as seen in IGP: Air quality starts to worsen in cities in river valleys like Guwahati and Agartala from the middle of October and remains poor even by the end of February. Same does not apply for the hilly towns but a spike in daily PM2.5 levels is registered among these as well during winters but in a more erratic fashion (See *Graph 8R6: Heatmap of air quality among Northeast Indian cities*). There is a big problem with data quality among the stations of the region as well. Most cities have data missing for multiple days.

Graph 8R6: Heatmap of air quality among Northeast Indian cities



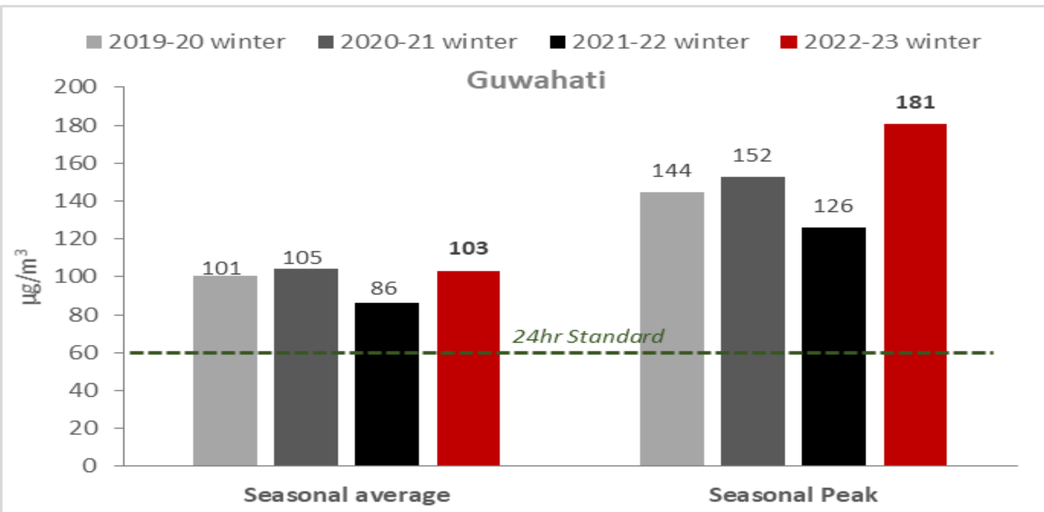
Note: Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB real-time data

Key findings: Cities

Assam: Guwahati

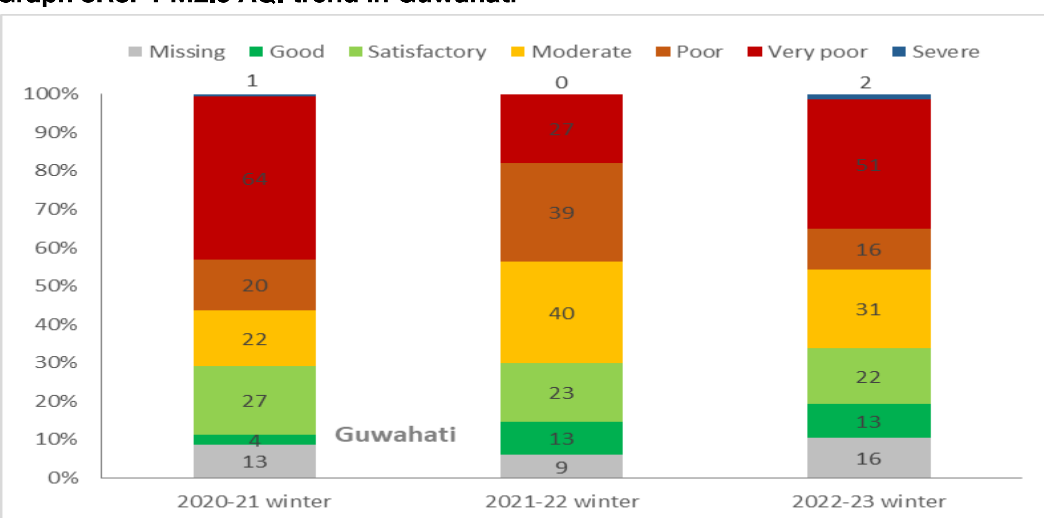
Winter pollution level in Guwahati this season has been 6 per cent higher than the mean of previous three winters and is considerably higher than the standard (See *Graph 8R7: PM2.5 winter trend in Guwahati*). Similarly, the seasonal peak is also increasing this winter, there has been a 28 per cent rise in winter peak compared to the mean of peaks of the previous three winters. AQI categorization shows that the city's air quality has deteriorated to two severe days this year. Also the city has recorded 51 very poor days but the number of days with poor air quality has decreased this winter compared to the last two winters (See *Graph 8R8: PM2.5 AQI trend in Guwahati).*

Graph 8R7: PM2.5 winter trend in Guwahati



Note: PM2.5 values are based on stations that have continuous and adequate data. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 8R8: PM2.5 AQI trend in Guwahati

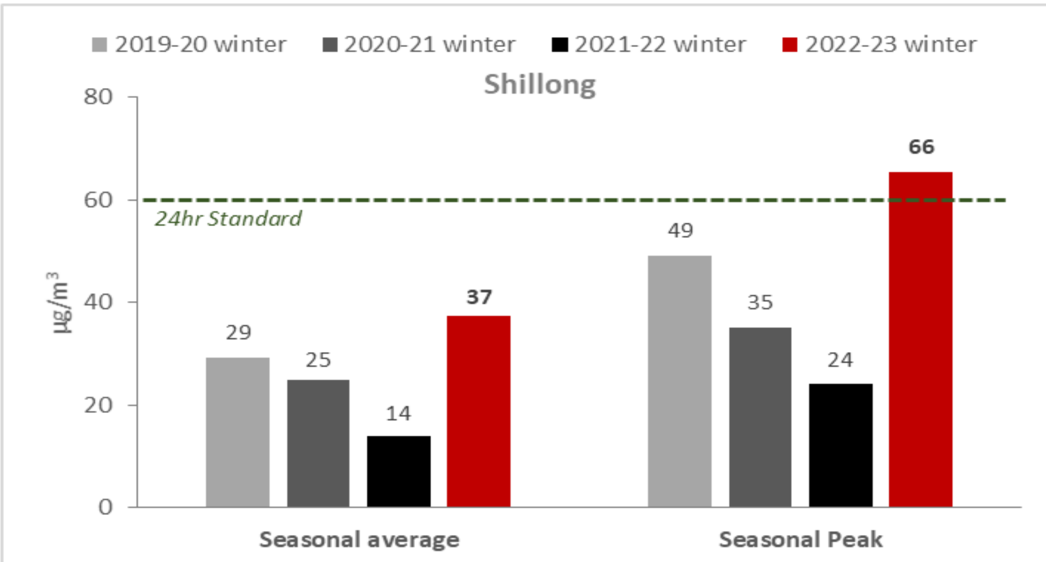


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Meghalaya: Shillong

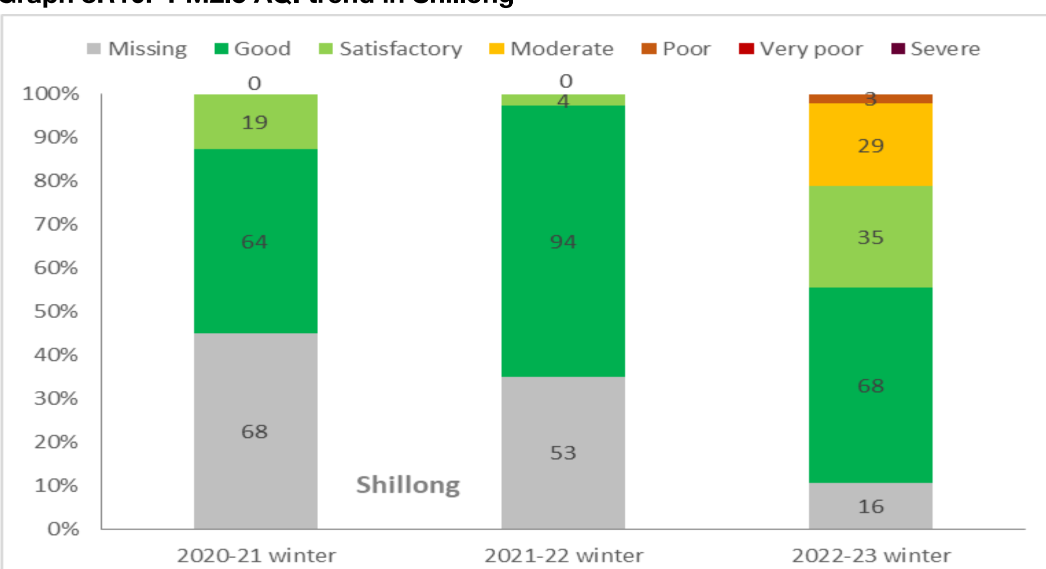
Winter pollution level in Shillong this season has been 64 per cent higher than the mean of previous three winters but it is lower than the standard. Also there has been an 82 per cent increase in winter peak compared to the mean of peaks of previous three winters (See *Graph 8R9: PM2.5 winter trend in Shillong).* AQI categorization shows that the city's air quality has not deteriorated to severe days in the last three years but the number of days with good air quality has decreased this winter compared to last year going from 94 to 68 good days (See *Graph 8R10: PM2.5 AQI trend in Shillong*).

Graph 8R9: PM2.5 winter trend in Shillong



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 8R10: PM2.5 AQI trend in Shillong

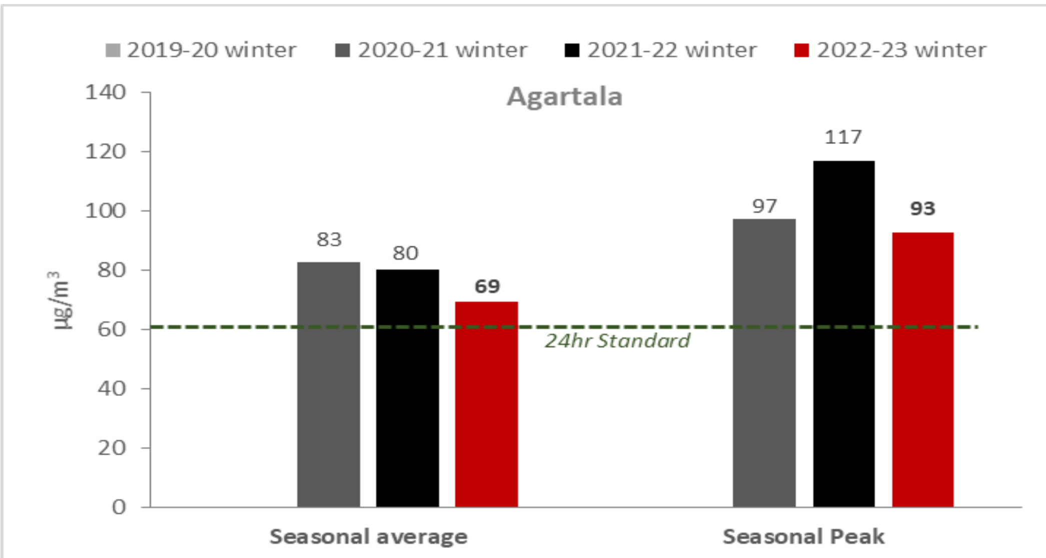


Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Tripura: Agartala

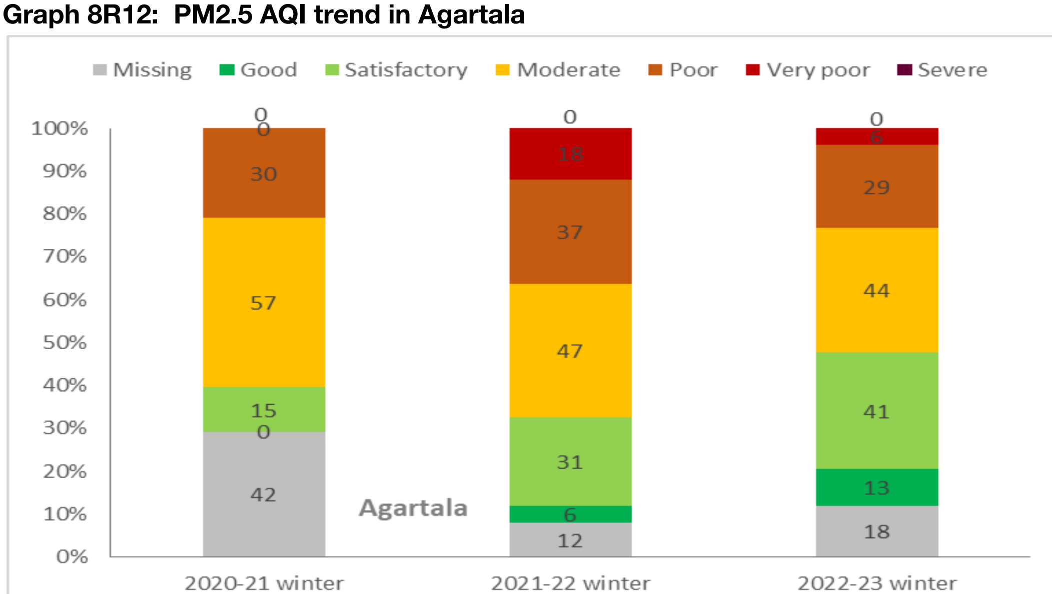
Winter pollution level in Agartala has been 15 per cent lower than the mean of previous two winters but is considerably higher than the standard. Also, there has been a decline in winter peak with 14 per cent compared to the mean of peaks of the previous two winters (See *Graph 8R11: PM2.5 winter trend in Agartala).* AQI categorization shows that the city's air quality has not deteriorated to severe days but the city has recorded 6 very poor days this year, a decrease compared to previous winters when it has recorded 18 very poor days. Also there is an increase in the number of good days this winter compared to the previous two winters (See *Graph 8R12: PM2.5 AQI trend in Agartala).*

Graph 8R11: PM2.5 winter trend in Agartala



Note: PM2.5 values are based on stations that have continuous and adequate data for complete assessment periods Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Graph 8R12: PM2.5 AQI trend in Agartala



Note: PM2.5 value is based on stations that have continuous and adequate data for complete assessment period. AQI is based on the PM2.5 sub-category only. Winter is defined as 1 October -28 February.
Source: CSE analysis of real-time data from CPCB portal

Annexure 8R

Winter PM2.5 level at station levels among Northeast Indian cities

	Station	State	2021-22 winter	2022-23 winter
1	Byrnihat_CentralAcademy	Assam		248
2	Agartala_Bardowali	Tripura		130
3	Nalbari_BataChowk	Assam		111
4	Guwahati_RailwayColony	Assam	86	103
5	Guwahati_LGBIAirport	Assam		102
6	Guwahati_IITG	Assam		93
7	Guwahati_PanBazaar	Assam	77	88
8	Agartala_Kunjaban	Tripura	80	69
9	Imphal_ManipurUniv	Manipur		66
10	Shillong_Lumpyngngad	Meghalaya	14	37
11	Kohima_PWD Junction	Nagaland	33	35
12	Gangtok_ZeroPoint_GICI	Sikkim		32
13	Sivasagar_GirlsCollege	Assam		23
14	Imphal_DM_College	Manipur		21
15	Naharlagun	Arunachal Pradesh	25	21
16	Aizwal_Sikulpuikawn	Mizoram	8	10

Note: October- February average is based on the mean of daily averages. All values are in µg/m^3. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB real-time data

Report 9

Delhi-NCR: Winter is here; overview of impending air quality crisis

As Delhi and the National Capital Region (NCR) braces for the upcoming winter it remains to be seen if the seasonal average of PM2.5 during winter that had improved during pandemic but stagnated post pandemic, will further bend or increase. This winter season is also starting from a much cleaner benchmark due to rains in September and October.

This has emerged from the latest winter analysis of the Urban Lab at Centre for Science and Environment (CSE). The objective has been to understand the trend and the starting line of the onset of the winter pollution season or pre-winter levels in this region. This also captures the longer term context of seasonal variation and annual trends in particulate pollution. This is the first analysis of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdown on air quality of Delhi and NCR.

The intensity of winter pollution and severity of smog episodes will depend on the effectiveness of the long term multi-sector action so far in the entire region of Delhi and NCR and also on the enforceability of the short term emergency action. Only the effectiveness of the air pollution control measures targeting all key sources will determine if the winter pollution trend that had stabilised post pandemic, will continue to hold and improve or worsen further.

The onset of the winter has been much cleaner this year due to the rains. But the intensity of the early winter pollution will depend a lot on the trend in the crop fires and also the impact of Diwali. Though Diwali is happening during the warmer part of the early winter, prolonged rains can delay and lead to concentrated burning later compounding the problem.

This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 January 2015 to 17 October 2022 (winter is defined as from October 1 to February 28). This captures seven successive winter seasons and pre-winter trends in Delhi and the National Capital Region. 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 the 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. 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).

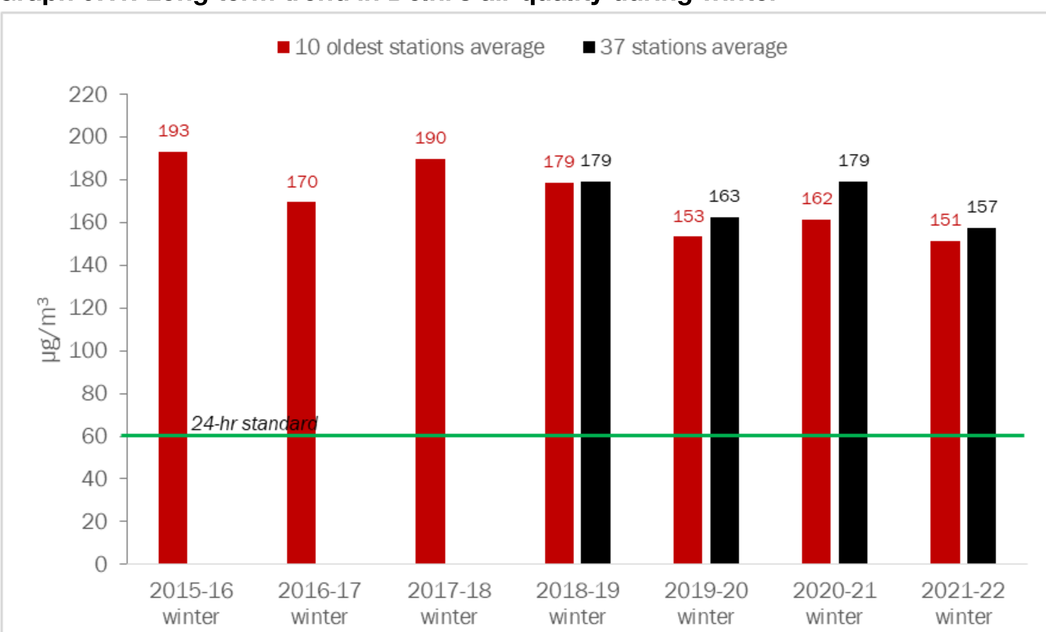
Key findings: Previous winters

Recent winters show about 20 per cent improvement in seasonal air quality compared to winters of 2015-18, but progress seems to have stagnated since pandemic: Delhi's seasonal air quality for winter (1 Oct to 28 Feb) used hover around 180-190 µg/m^3 before pandemic and for last three winters it has come down to 150-160 µg/m^3 (See *Graph 9R1: Long term trend in Delhi's air quality during winter)*. Despite the improvement the seasonal average is still over 150 per cent above the 24-hr standard and almost 4-times the annual standard.

Peak pollution shows a similar trend as seasonal average. Peak pollution (worst 24-hr average) used to cross 800 µg/m^3 at individual stations pre-pandemic, it has been hovering in 700-800 µg/m^3 range during last three winters (See *Graph 9R2: Long term trend in Delhi's peak pollution level during winter*). These peak pollution numbers should be taken with caution as CPCB introduced a 1,000 µg/m^3 cap on reported real-time data in 2016-17, which has greatly compromised the assessment of peak pollution level. Actual peak levels must be higher than what CPCB data shows.

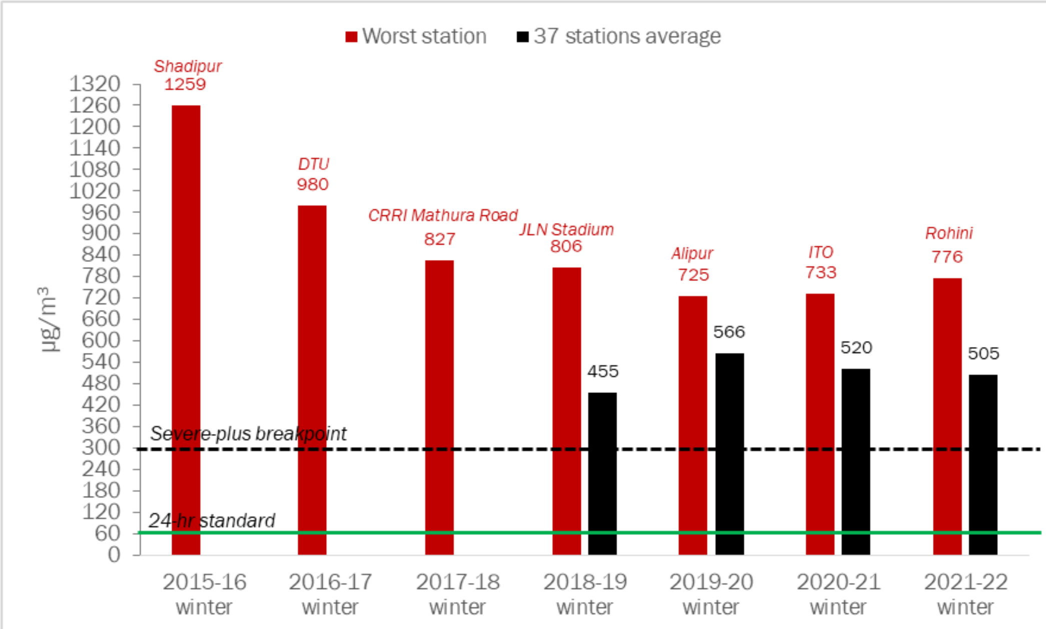
It must also be noted that the worst station for peak pollution has changed 7 times in the last seven winters. Shadipur, DTU, CRRI Mathura Road, JLN Stadium, Alipur, ITO and Rohini have occupied the worst peak pollution title in the last seven winters. These are spread across the city with no clear pattern. This indicates that the winter pollution is regional in nature and short-term peak build-up can happen anywhere based on local meteorology and pollution sources.

Graph 9R1: Long term trend in Delhi's air quality during winter



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. 37 station average includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. Seasonal average is based on the mean of monthly averages. Winter season is defined as October to February.
Source: CSE analysis of CPCB realtime data

Graph 9R2: Long term trend in Delhi's peak pollution level during winter

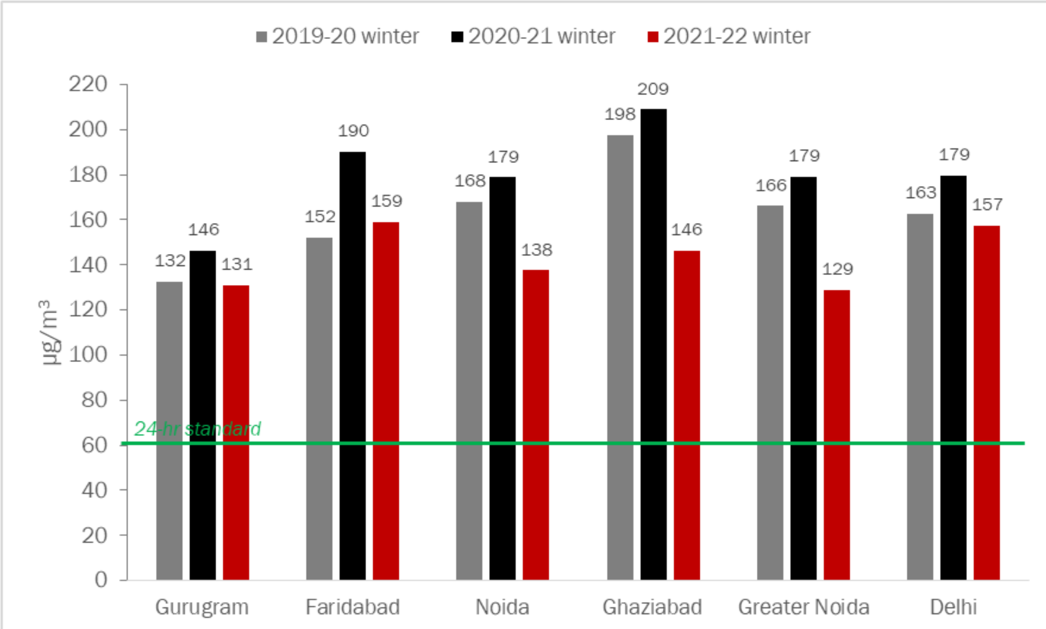


Note: 37 station average includes all the Delhi stations except Lodhi Road IITM, Chandni Chowk IITM and East Arjun Nagar. Peak level is based on 24-hour averages calculated from midnight to midnight. Winter season is defined as October to February.
Source: CSE analysis of CPCB realtime data

Last winter was 10-30 per cent less polluted compared to the 2020-21 winter for most major NCR cities, Ghaziabad and Faridabad have had the worst winter air among major NCR cities: Winter of 2021-22 was relatively less polluted compared to winter of 2020-21 for most NCR cities. Ghaziabad registered a 30 per cent improvement that was highest among major cities but its PM2.5 level was still about 2.5-times the 24-hr standard (See *Graph 9R3: Last three winter's PM2.5 level among major cities of core NCR*). Greater Noida (28 per cent), Noida (23 per cent) and Faridabad (16 per cent) also registered improvement in excess of Delhi that registered 12 per cent improvement. Gurugram with 11 per cent improvement was the worst performer among the core NCR cities. In absolute concentration terms, Faridabad with a seasonal average of 159 µg/m^3 was the most polluted city of NCR last winter.

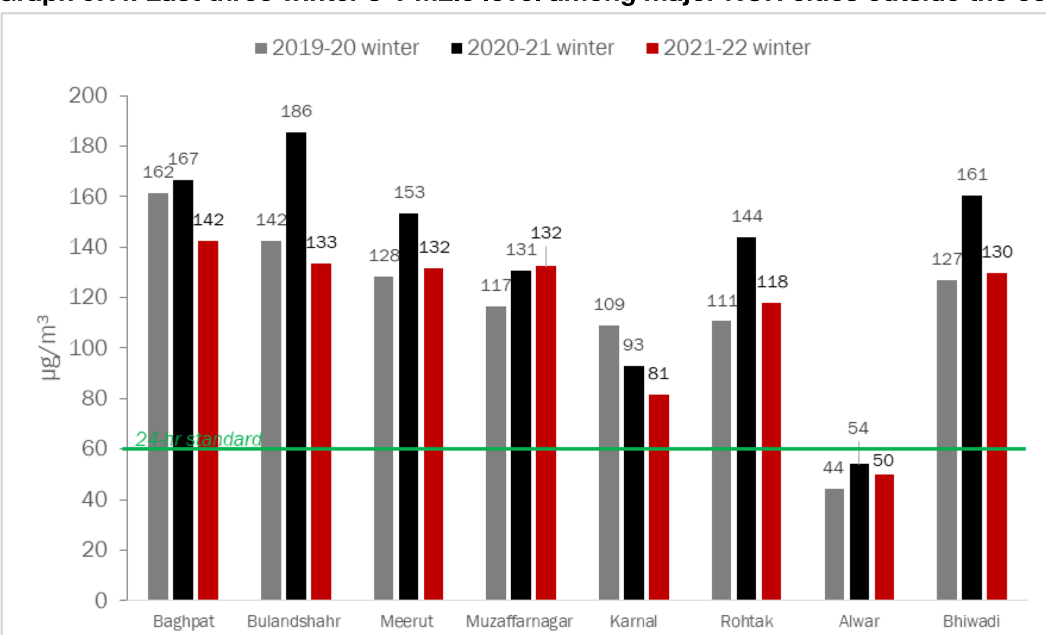
Across the larger NCR, Muzaffarnagar was the worst performer as it registered one per cent increase in winter level (See *Graph 9R4: Last three winter's PM2.5 level among major NCR cities outside the core*). Bulandshahr with 28 per cent improvement was the best performer among major non-core NCR cities. Baghpat with seasonal average of 142 µg/m^3 was the most polluted city outside the core-NCR. Alwar with a winter average of 50 µg/m^3 was the only major city in NCR that registered a seasonal level lower than the 24-hr standard.

Graph 9R3: Last three winter's PM2.5 level among major cities of core NCR



Note: Seasonal average is based on the mean of monthly averages recorded at CAAQM stations in the city that have adequate data for all three winters. Delhi is represented by its 10 oldest stations (Anand Vihar, CRRI Mathura Road, IGI Airport T3, IHBAS, Mandir Marg, DU North Campus, NSIT Dwarka, Punjabi Bagh, RK Puram and Shadipur). Gurugram by Gwal Pahari and Vikas Sadan stations; Faridabad by Sector 16A station; Noida by Sector 125 and Sector 62 stations; Ghaziabad by Vasundhara station; and Greater Noida by KP-III station. Winter season is defined as October to February.
Source: CSE analysis of CPCB realtime data

Graph 9R4: Last three winter's PM2.5 level among major NCR cities outside the core



Note: Seasonal average is based on the mean of monthly averages recorded at CAAQM stations in the city that have adequate data for all three winters. Except Meerut all cities have only one station and are represented by them. Meerut is represented by the mean of its three stations. Winter season is defined as October to February.
Source: CSE analysis of CPCB realtime data

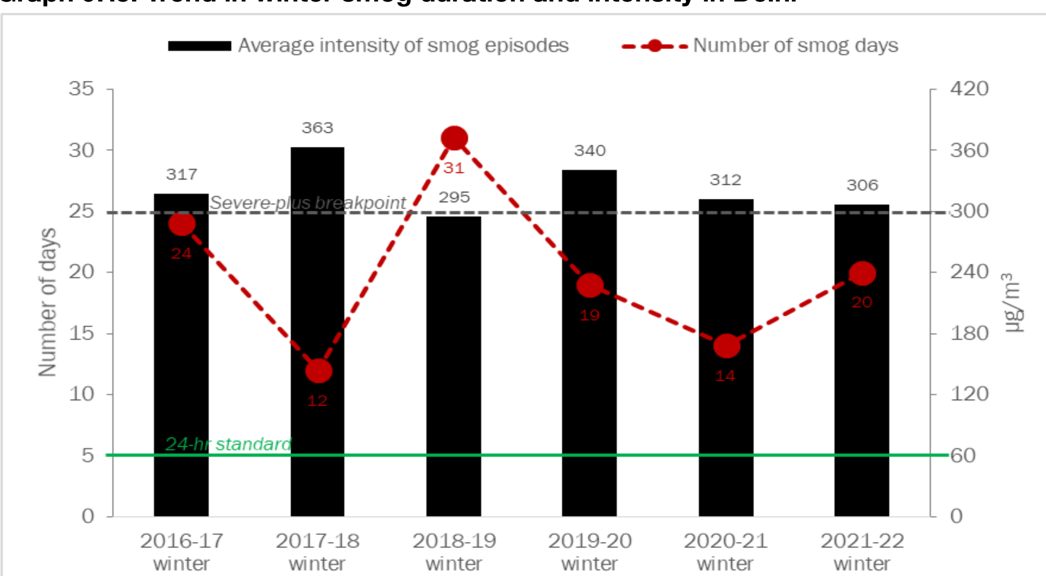
<u>Smog days and intensity remain worrisome</u>: A smog episode is defined for the purpose of emergency action under Delhi's Graded Response Action Plan when the levels of PM2.5 remain in "severe" category for three consecutive days. In this study, if two consecutive smog episodes are separated by only one day and the PM2.5 level of that day doesn't drop below 200 µg/m^3 then the whole period is considered a single extended smog episode. Last winter season, there were three distinct smog episodes totaling 20 smog days (See *Table 1: Smog episodes in Delhi*). This was more than previous two winters. 2020-21 winter had 14 smog days while 2019-20 winter had 19 smog days (See *Graph 9R5: Trend in winter smog duration and intensity in Delhi*). Most smog days were observed in the 2018-19 winter when 4 smog episodes were recorded with a total of 31 smog days. Average intensity of smog episode last winter was 306 µg/m^3 which is lower than previous two winter smog episodes but this marginally lower intensity is negated by the longer duration of the smog episodes. It must be noted that winters with relatively lower seasonal averages have longer and more smog episodes (See *Table 9R1: Smog episodes in Delhi*). Which is a fascinating occurrence and requires deeper investigation.

Table 9R1: Smog episodes in Delhi

Winter	Seasonal PM2.5 average	Total smog days	1st smog episode	2nd smog episode	3rd smog episode	4th smog episode
2016-17	170 µg/m^3	24	27 Oct-11 Nov	29 Nov-2 Dec	6-9 Dec	
2017-18	190 µg/m^3	12	7-14 Nov	30 Dec-2 Jan		
2018-19	179 µg/m^3	31	8-13 Nov	20 Dec-5 Jan	11-13 Jan	16-20 Jan
2019-20	153 µg/m^3	19	28 Oct-4 Nov	11-15 Nov		
2020-21	162 µg/m^3	14	4-10 Nov	4-7 Dec	22-24 Dec	
2021-22	151 µg/m^3	20	4-13 Nov	25-28 Dec	21-26 Dec	

Note: A smog episode is defined for the purpose of emergency action under Delhi's Graded Response Action Plan when the levels of PM2.5 remain in the "severe" category for three consecutive days. If two consecutive smog episodes are separated by only one day and the PM2.5 level of that day doesn't drop below 200 µg/m^3 then the whole period is considered a single smog episode.
Source: CSE analysis of CPCB realtime data

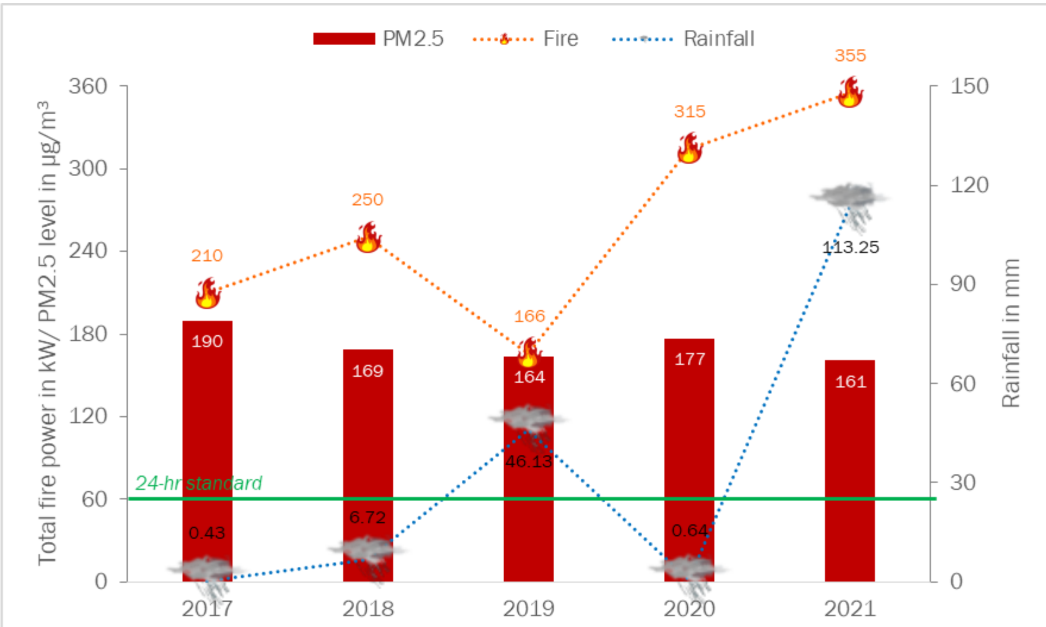
Graph 9R5: Trend in winter smog duration and intensity in Delhi



Note: Based on 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. A smog episode is defined for the purpose of emergency action under Delhi's Graded Response Action Plan when the levels of PM2.5 remain in the "severe" category for three consecutive days. If two consecutive smog episodes are separated by only one day and the PM2.5 level of that day doesn't drop below 200 µg/m^3 then the whole period is considered a single smog episode.
Source: CSE analysis of CPCB realtime data

Impact of rain and farm stubble fire smoke on the air quality is highly pronounced: Each year air in October and November become unbreathable due to unfortunate clustering of pollution causing and compounding events. Festive season leads to increase in local pollution due to traffic chaos and firecrackers which is compounded by cooling of weather that lower mixing height and sets in inversion. Burning of crop waste in Punjab and Haryana further adds to the pollution load, which is compounded by retreating monsoon which transports the smoke down the Gangetic Plains. Only sobering element during these two months is rain, which can wash down the pollution if the downpour is strong and prolonged. Albeit it is only a temporary relief. This relationship is evident from the data (See *Graph 9R6: Relationship among rain, farm stubble fires, and Delhi's air quality in Oct-Nov*).

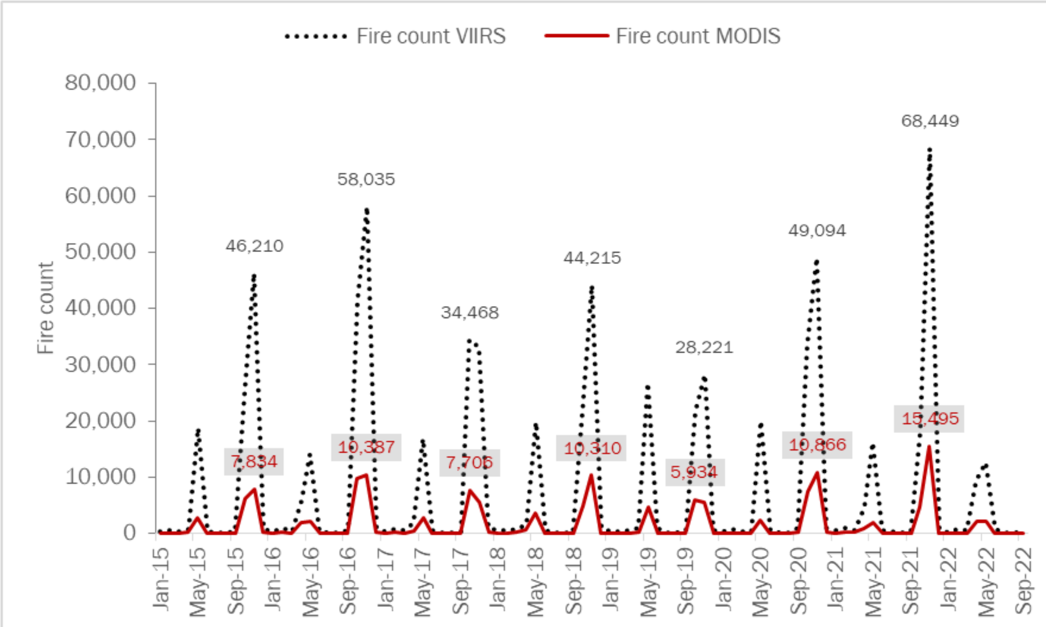
Graph 9R6: Relationship among rain, farm stubble fires, and Delhi's air quality in Oct-Nov



Note: PM2.5 level is based on 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. Fire data is based on NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) product and is for Punjab, Haryana and Delhi. Rainfall data is from IMD's station at Palam.
Source: CSE analysis

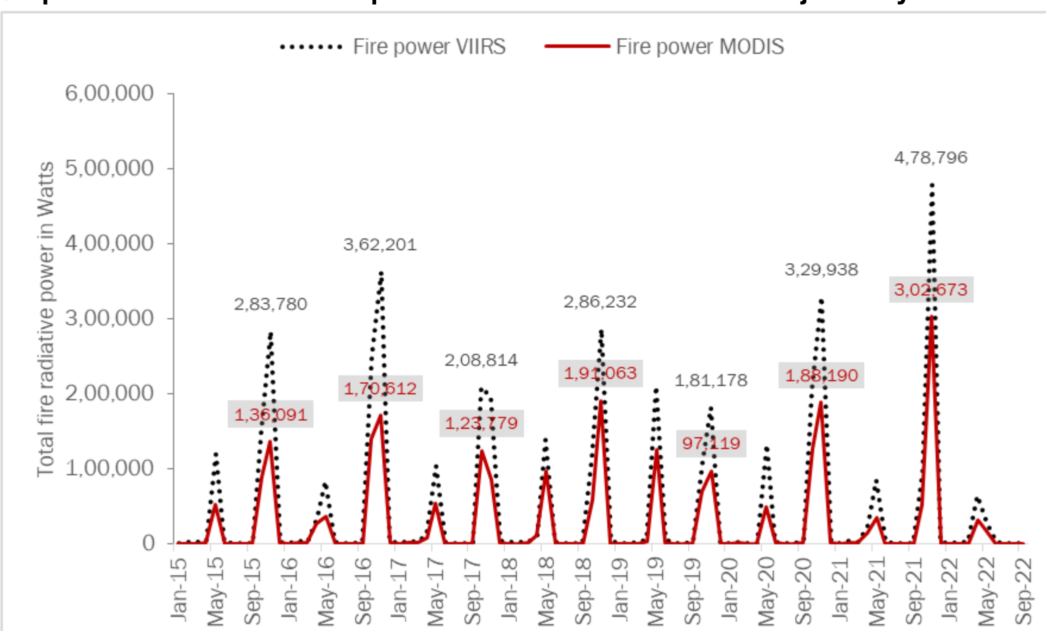
Farm stubble fires of Punjab-Haryana-Delhi are increasing both in numbers and intensity: Last year registered the highest instances of farm stubble fires in the last seven years. 2021 October-November saw 10 per cent increase in observed fire count by MODIS and 5 per cent increase by VIIRS compared to 2020 October-November (See *Graph 9R7: Trend in farm stubble fire count in Punjab-Haryana-Delhi 2015-22*). Similarly, the total fire radiative power from these fires were 13 per cent and 7 per cent higher compared to 2020 October-November fire as observed by MODIS and VIIRS respectively (See *Graph 9R8: Trend in radiative power of farm stubble fires in Punjab-Haryana-Delhi 2015-22*). In fact there is a consistent increase in fire instances and intensity since 2019.

Graph 9R7: Trend in farm stubble fire count in Punjab-Haryana-Delhi 2015-22



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 1 October 2022.
Source: CSE analysis

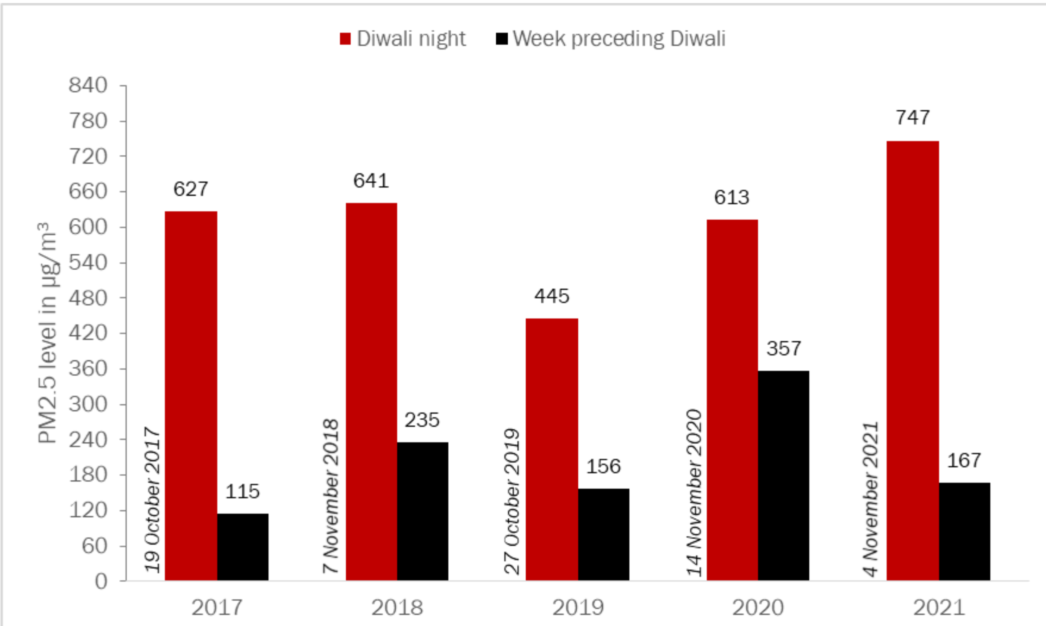
Graph 9R8: Trend in radiative power of farm stubble fires in Punjab-Haryana-Delhi 2015-22



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 1 October 2022.
Source: CSE analysis

<u>Diwali night pollution continues to remain high</u>: PM2.5 concentration at the Diwali night (8pm to 8am) last year stood at 747 µg/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 (See *Graph 9R9: PM2.5 levels Diwali-night (8pm-8am) vs average of nights in the week preceding Diwali*). Please note that this Diwali night value is an undercount as CPCB caps PM2.5 data at 1,000 µg/m³. It is noted that hourly concentrations can go beyond 1,000 µg/m³. This year 26 of 38 operational monitoring stations hit the 1,000 µg/m³ mark. In 2020, 23 out of 38 stations had hit the 1,000 µg/m³ mark while in 2019 the number stood at 22 stations.

Graph 9R9: PM2.5 levels Diwali-night (8pm-8am) vs average of nights in the week preceding Diwali



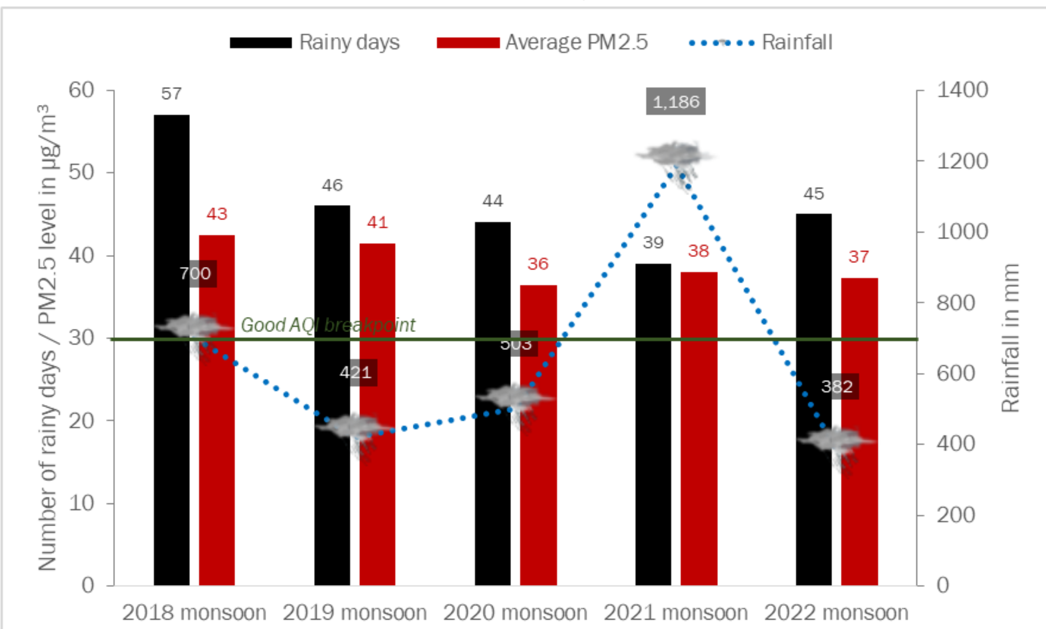
Note: Average PM2.5 concentration is based on the mean of 12hr values recorded at Delhi's 37 CAAQM stations (2017 Diwali data is based on a lesser number of stations). Nighttime is 8pm to 8am. Pre-diwali night average is the mean of nighttime levels of seven preceding nights.
Source: CSE analysis of CPCB's real time air quality data

Key findings: Start of 2022-23 winter

2022 monsoon was the second cleanest in last 8 years despite relatively lesser rain and unusually polluted summer: The seasonal average for the monsoon (July, August and September) this year stood at 37 µg/m^3 which is only marginally higher than lowest monsoon average of 36 µg/m^3 that was recorded during 2020 monsoon (See *Graph 9R10: Trend in PM2.5 and rainfall during monsoon season in Delhi*). The ultra-low pollution levels recorded during the 2020 monsoon were preceded by cleanest ever summer (March-May) due to extraordinary conditions created because of hard pandemic lockdowns. But this monsoon has been preceded by one of the most polluted summers, therefore it is important to understand what aided in cleaning up the Delhi air.

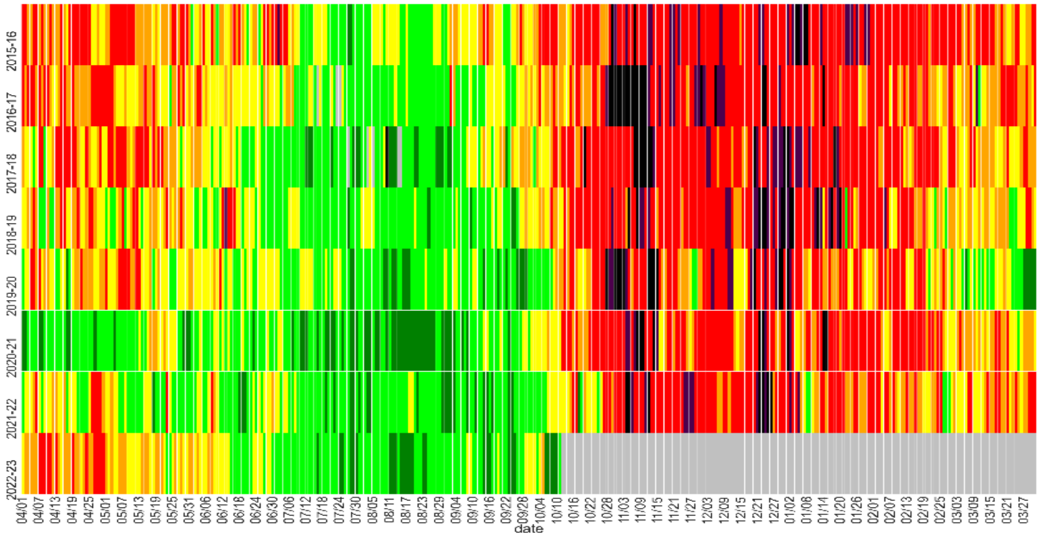
Looking at the rainfall data it becomes evident that distribution of rainfall has a relatively higher impact on seasonal air quality than the absolute quantity of rainfall. This monsoon there have been 45 rainy days compared to just 39 rainy days in the previous monsoon. These six extra rainy days help keep the seasonal average low despite total rainfall this monsoon having been just one-third of previous monsoon. These additional rainy days also pushed the regular start of bad air quality days further down the month of October (See *Graph 9R11: Air quality heatmap of Delhi*).

Graph 9R10: Trend in PM2.5 and rainfall during monsoon season in Delhi



Note: PM2.5 level is based on the mean of 37 stations of Delhi. Rainfall data is from IMD's station at Palam.
Source: CSE analysis

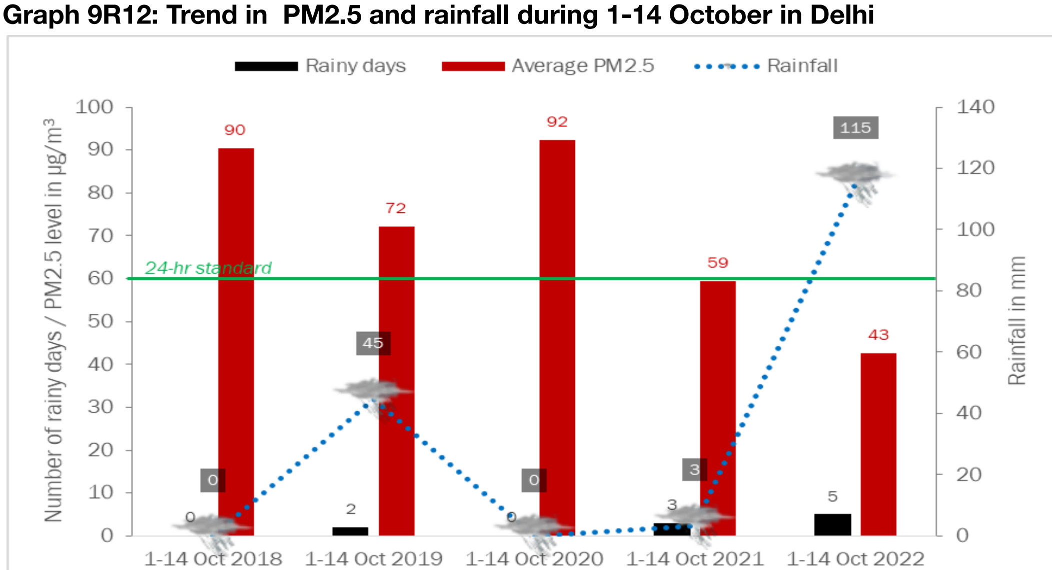
Graph 9R11: Air quality heatmap of Delhi



Note: PM2.5 level is based on 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. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis

Rains kept air quality in check during the first two weeks of October: Delhi received unprecedented 115 mm of rainfall in the first two weeks of October this year, this translated into the cleanest start to winter since wide-scale monitoring started in 2018. The PM2.5 average for the first two weeks of October stood at 43 µg/m^3 which is less than half of the level recorded in 2020 for the same period (See *Graph 9R12: Trend in PM2.5 and rainfall during 1-14 October in Delhi*). This October so far there have been five days of "Good" AQI (PM2.5 sub-category) which is the most recorded in the last eight winter seasons. All these "good" AQI days fell on rainy days. Last year two "good" AQI days were recorded for the entire winter season, previous winters had no "good" AQI days.

Graph 9R12: Trend in PM2.5 and rainfall during 1-14 October in Delhi

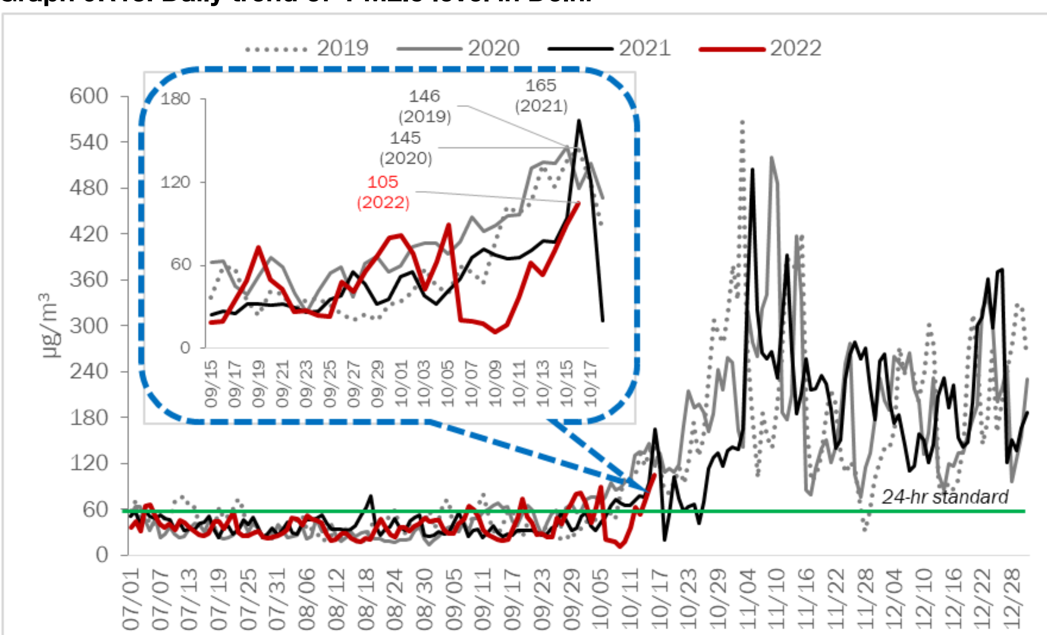


Note: PM2.5 level is based on the mean of 37 stations of Delhi. Rainfall data is from IMD's station at Palam.
Source: CSE analysis

Air quality is starting to deteriorate: Relief given by extended rainfall period has come to an end as PM2.5 level has risen above 100 µg/m^3 on 16th October (See *Graph 9R13: Daily trend of PM2.5 level in Delhi*). This is still low compared to previous years but it is expected to rise quickly. This rise is being driven by smoke from the farm stubble fires starting to enter the region. As per SAFAR, this smoke contributed about 3 per cent to Delhi's PM2.5 level on 17th October. This is a relatively low contribution compared to previous years for this time of the year (See *Graph 9R14: Daily trend of farm stubble fire smoke's contribution to PM2.5 level in Delhi*). This is happening now because burning activities have picked up in Punjab-Haryana-Delhi. The total radiative fire power of these fires in Punjab-Haryana-Delhi breached 2,000 Watt on 16th October, which is less than half of the value recorded in 2020 and 2021 for same period (See *Graph 9R15: Daily trend of farm stubble fire's radiative power, Punjab-Haryana-Delhi*). Based on previous years' observations it can be said that the situation will worsen dramatically if the business as usual scenario continues. In fact, Diwali celebrations next week will accelerate this deterioration.

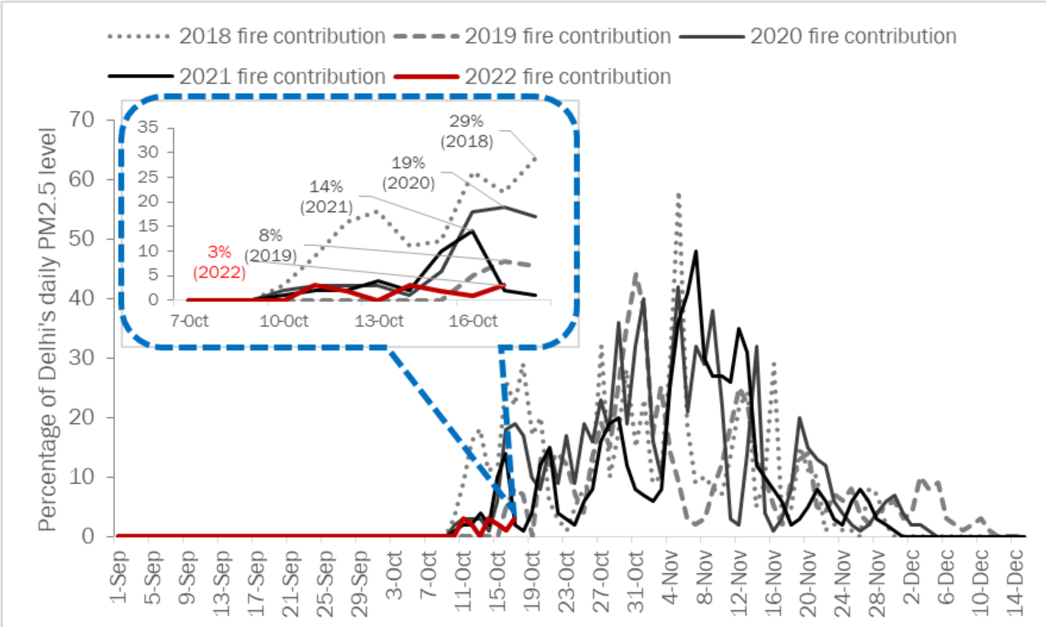
This Diwali might yet again trigger a deadly smog episode: This year Diwali is falling relatively early in the season which means the warmer and windier conditions will help dilute the pollution that is staple of Diwali night celebrations. Unlike previous two years, the smoke from the farm stubble fires has not overwhelmed the air quality of the region yet and rains in early October have also kept the air relatively clean so far. But based on previous years data it is expected that Diwali night can add 300-600 µg/m^3 of PM2.5 to Delhi's air if the business as usual scenario continues. There is very high likelihood that farm stubble fire will drastically increase as well during the days leading to Diwali and will continue post Diwali. Delayed start of the burning season in the past has resulted in concentration of burning activities which will intensify the smoke-fall in the region. In short, conditions are ripe for a severe smog episode to start from Diwali night.

Graph 9R13: Daily trend of PM2.5 level in Delhi



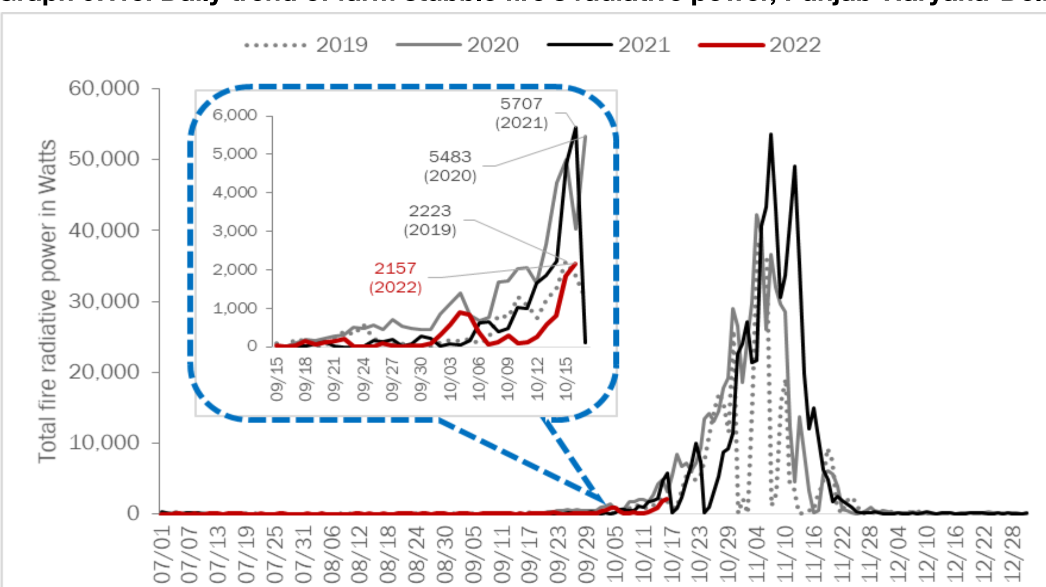
Note: PM2.5 level is based on the mean of 37 stations of Delhi. Data up till 17 October 2022.
Source: CSE analysis

Graph 9R14: 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 based on the SAFAR India publication.
Data up till 17 October 2022.
Source: CSE analysis

Graph 9R15: Daily trend of farm stubble fire's radiative power, Punjab-Haryana-Delhi



Note: Fire data is based on NASA's Visible Infrared Imaging Radiometer Suite (VIIRS) product. It covers Punjab, Haryana and Delhi.
Data up till 17 October 2022.
Source: CSE analysis

Way forward

This early winter alert is a wake-up call for more stringent pre-emptive and preventive measures to avert the smog episodes that cause excessive exposure and health risk during winter. The enforcement of the graded response action plan needs to be equally stringent with zero tolerance across Delhi and NCR. This requires preparedness in all concerned departments to ensure:

- All waste streams are collected, segregated and transported to prevent accumulation of waste in the open. Ongoing legacy waste management needs additional measures to ensure that dumpsites do not catch fire.
- Access to clean fuels in industry needs to be scaled up and units without air pollution control equipment or consent to operate are not allowed to function.
- Intensify public transport strategies and enforce parking controls and pricing as a demand management measure to reduce vehicle usage. Incentivise use of electric vehicles.
- Identify key commercial areas in Delhi and NCR towns that can be pedestrianised and be declared low emission zones.
- Dust control in construction sites and management of construction and demolition waste is implemented with zero tolerance.
- Disclose data on the truck movement based on the RFID data set to inform and control the intensity of the heavy duty traffic in the city.
- Identify all unpaved roads and dust hotspots for immediate action and paving.
- Equally stringent measures are needed to control fugitive dust and industrial waste burning and the mechanism needs to be put in place for all industrial areas.
- Step up action to provide access to LPG and electricity to all eateries and households to prevent burning of solid fuels.
- Ensure access to reliable electricity supply in all residential and commercial/industrial areas to minimise use of diesel generator sets. Make DISCOMS liable and accountable for the outages in Delhi and entire NCR.

Annexure 9R

Winter PM2.5 level at city levels among cities of Delhi-NCR

	City	1-14 Oct 2022	2021-22 winter	2020-21 winter
1	Dharuhera, HR	62	106	142
2	Baghpat, RJ	59	142	166
3	Meerut, RJ*	59	134	159
4	Ghaziabad, UP*	55	167	213
5	Bhiwadi, RJ	55	130	161
6	Manesar, HR	49	143	123
7	Gurugram, HR*	49	137	148
8	Bulandshahr, RJ	48	133	185
9	Greater Noida, UP*	47	128	185
10	Delhi, DL*	47	157	179
11	Charkhi Dadri, HR	46	116	127
12	Muzaffarnagar, RJ	46	133	126
13	Hapur, RJ	46	135	61
14	Faridabad, HR*	44	152	156
15	Bahadurgarh, HR	43	122	142
16	Bhiwani, HR	43	102	41
17	Noida, UP*	40	141	188
18	Jind, HR	39	125	145
19	Ballabgarh, HR	39	128	109
20	Narnaul, HR	36	82	95
21	Rohtak, HR	34	118	143
22	Panipat, HR	32	73	88
23	Palwal, HR	30	44	48
24	Karnal, HR	28	81	93
25	Alwar, RJ	26	50	54
26	Sonipat, HR	24	66	84
27	Mandikhera, HR	17	57	80

Note: Seasonal average is based on the mean of monthly averages. Winter season is defined as October to February. All values are in µg/m^3. *Cities with multiple stations, average of all stations is used to represent the city.
Source: CSE analysis of CPCB realtime data

Report 10

Delhi-NCR: Midway through the winter; overview of air quality during October-November 2022

Half way through the winter the Urban Lab at Centre for Science and Environment (CSE) has analysed air quality trends so far in Delhi and the National Capital Region (NCR). The objective has been to understand the behaviour of the winter pollution in this region this October and November. This also helps to locate the winter season within the longer term context of seasonal variation and annual trends in particulate pollution. This is the first analysis of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in the 2020-21 winter to study the impact of pandemic lockdowns on Delhi's air quality.

This is an assessment of annual and seasonal trends in PM2.5 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 the 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. 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).

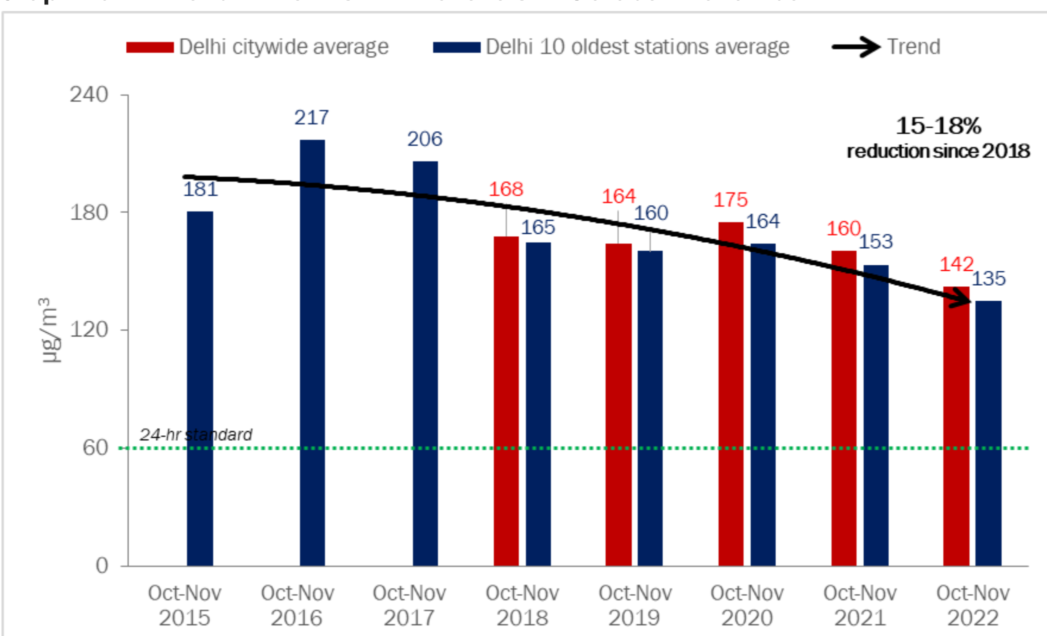
This winter started on the cleanest note with five "good" AQI days in the first two weeks of October. This happened due to an extended rainfall period. These good meteorological conditions were complimented by reduced quantity and intensity of farm stubble fires which led to the first smog free October-November in the last 5 years. The pollution level so far has been lowest compared to previous five-eight years but it is expected to rise as weather gets colder and calmer. This rise will be driven by local pollution in the region. As per SAFAR, this smoke contributed from burning activities in Punjab-Haryana-Delhi to Delhi's PM2.5 level has gone down to zero as of November 4, 2022. Based on previous years' observations it can be said that the situation will worsen dramatically if the business as usual scenario continues.

Key findings

October-November was the least polluted in the last 8 years: The average PM2.5 level across 37 functional CAAQMS stations of Delhi stood at 142 µg/m³ for months of October and November. This is the lowest level recorded since the city installed these 37 stations in 2018. If data for 10-oldest stations that have been working since 2014-15 is referred to, even then October-November of this year is least polluted in comparison (See *Graph 10R1: Trend in Delhi's PM2.5 levels in October-November*).

The PM2.5 level this October-November has been 15 per cent and 18 per cent lower compared to October-November of 2018 from a 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 the last eight years.

Graph 10R1: Trend in Delhi's PM2.5 levels in October-November



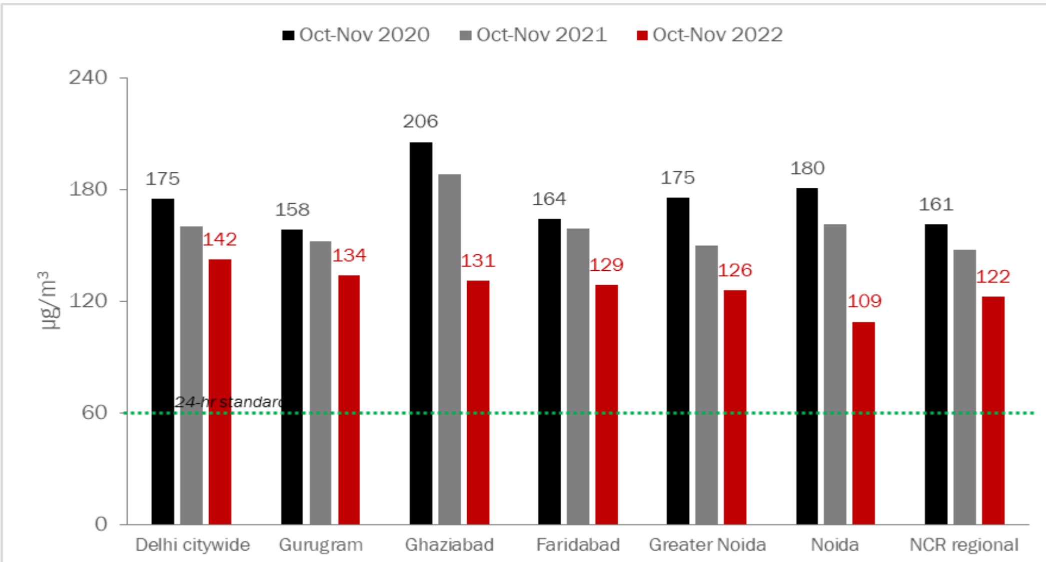
Note: 10 oldest stations of Delhi are Anand Vihar, CRRI Mathura Road, IGI Airport T3, IHBAS, Mandir Marg, DU North Campus, NSIT Dwarka, Punjabi Bagh, RK Puram and Shadipur. Delhi citywide average is based on 37 station average including all the Delhi stations except Lodhi Road IITM, Chandni Chowk and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

All major cities of Delhi-NCR registered least polluted October-November in the last three years: Ghaziabad's October-November average PM2.5 this year is 36 per cent lower than its 2020 level. Similarly, Greater Noida (28 per cent) and Faridabad (22 per cent) registered improvement in air quality in excess of Delhi's citywide performance. Gurugram shows least improvement with just 15 per cent change (See *Graph 10R2: Trend in PM2.5 levels in October-November for major NCR cities*). Nodia's October-November average PM2.5 this year appears to be 40 per cent lower than its 2020 level but there are concerns that one of Nodia's CAAQMS stations is reporting uncharacteristically low values this season which puts a doubt on the actual performance of Nodia.

Delhi was the most polluted major city in NCR with an October-November average of 142 μg/m^3. Gurugram with 134 μg/m^3 and Ghaziabad with 131 μg/m^3 were the next most polluted in NCR.

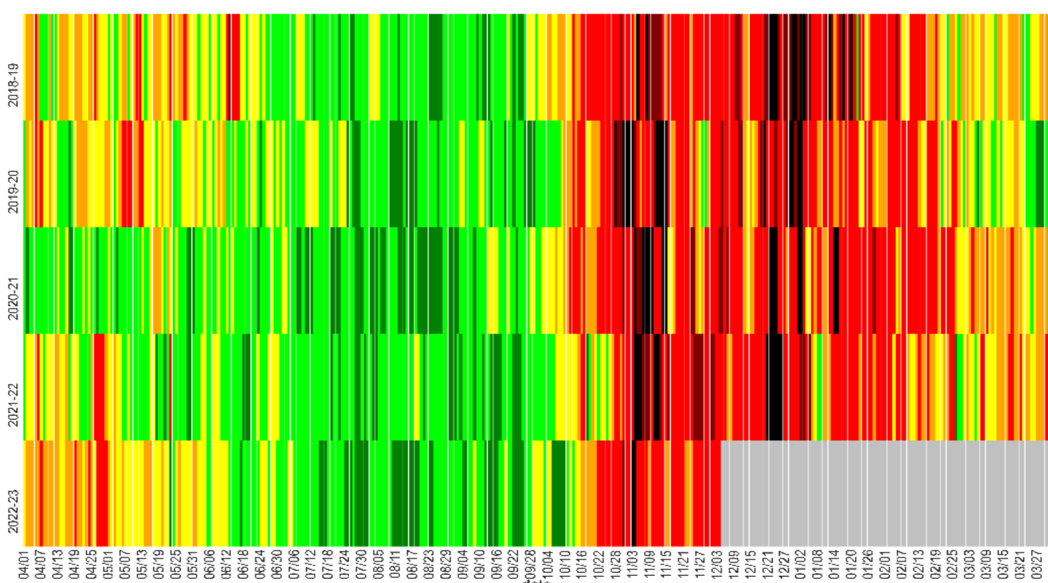
No smog episodes this season so far: There is usually one smog episode (three continuous days of severe AQI) during October-November lasting 6-10 days. This October-November no smog episode was recorded in the city (See *Graph 10R3: Air quality calendar of Delhi*). This makes October-November the first in the last five years to be smog free.

Graph 10R2: Trend in PM2.5 levels in October-November for major NCR cities



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

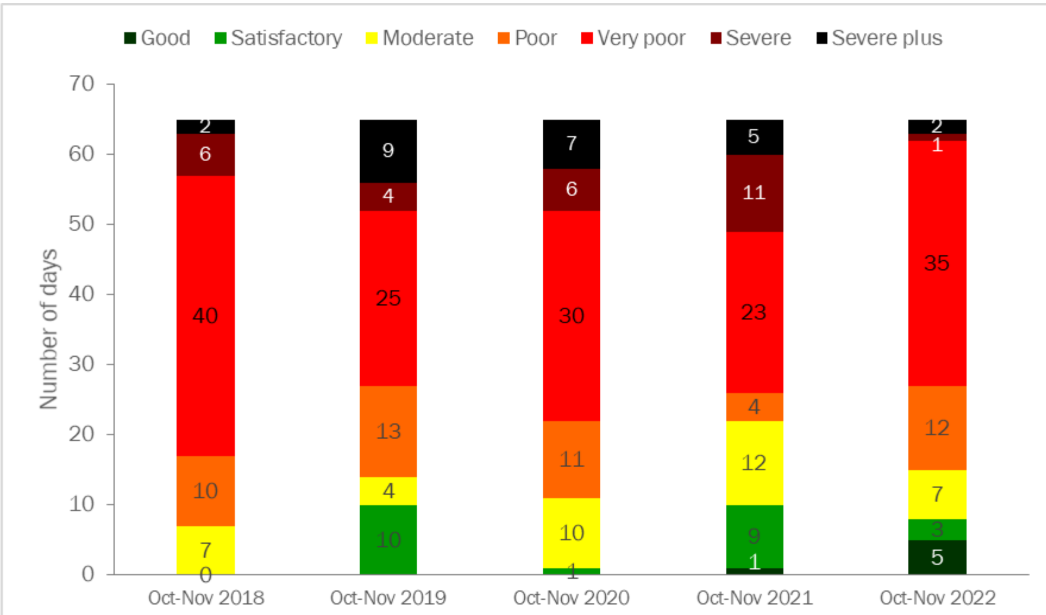
Graph 10R3: Air quality calendar of Delhi



Note: PM2.5 level is based on an 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

Five good air days recorded this October-November, highest in last five years: Heavy rainfall in October this year resulted in city recording five days of good air quality (PM2.5 lesser than 30 µg/m^3), most in last five years (See *Graph 10R4: 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 2018, 2019 and 2020. Only 3 days of severe or severe-plus days have been recorded so far, which is again the lowest in the last 5 years.

Graph 10R4: Distribution of October-November days as per AQI category for Delhi



Note: PM2.5 level is based on an 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

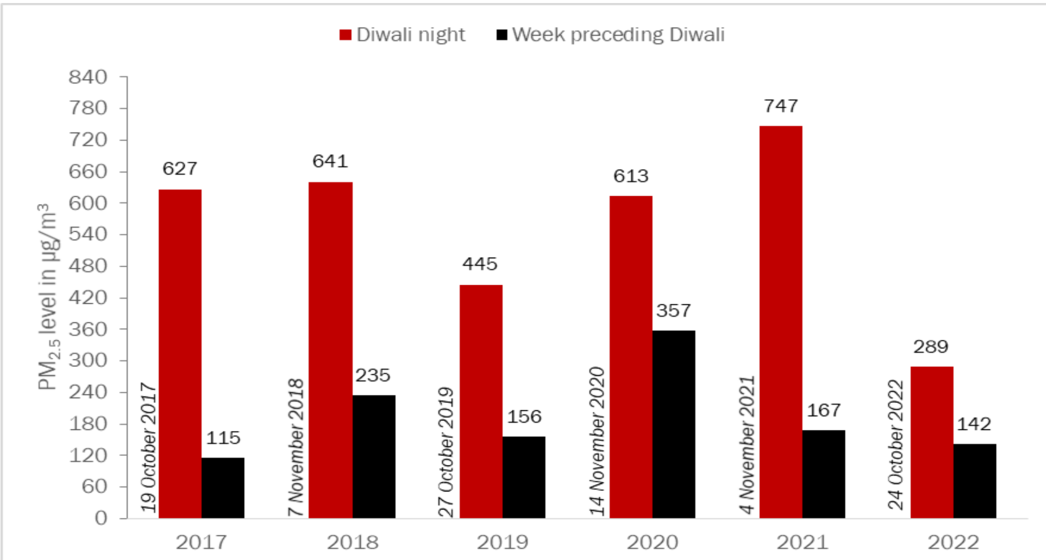
Least polluted Diwali in last six years: PM2.5 concentration at the Diwali night (8pm to 8am) this year stood at 289 µg/m^3, a good 61 per cent lower than last year's Diwali night when it stood at 747 µg/m^3. Diwali night PM2.5 levels almost double of the average night-time levels recorded in the week preceding Diwali. 2021 Diwali night levels were 4.5 times the average night-time levels recorded in the week preceding Diwali (See *Graph 10R5: Trend in Diwali night pollution in Delhi*). This is a combined effect of Diwali happening much earlier in the season compared to previous years and a changing attitude toward firecrackers among the citizens.

Farm stubble fires this year about half of last 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 10R6: 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 a measure of intensity of fire) is taken into account in addition to the number of fires, 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 10R7: Trend in farm stubble fire power in Punjab, Haryana and Delhi during Oct-Nov*). 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 the 2019 season. Therefore, it can be argued that the spike seen in the fires since pandemic started has ended and the situation has reverted to pre-pandemic scenario. This is a relatively better scenario but still far from clean air objective.

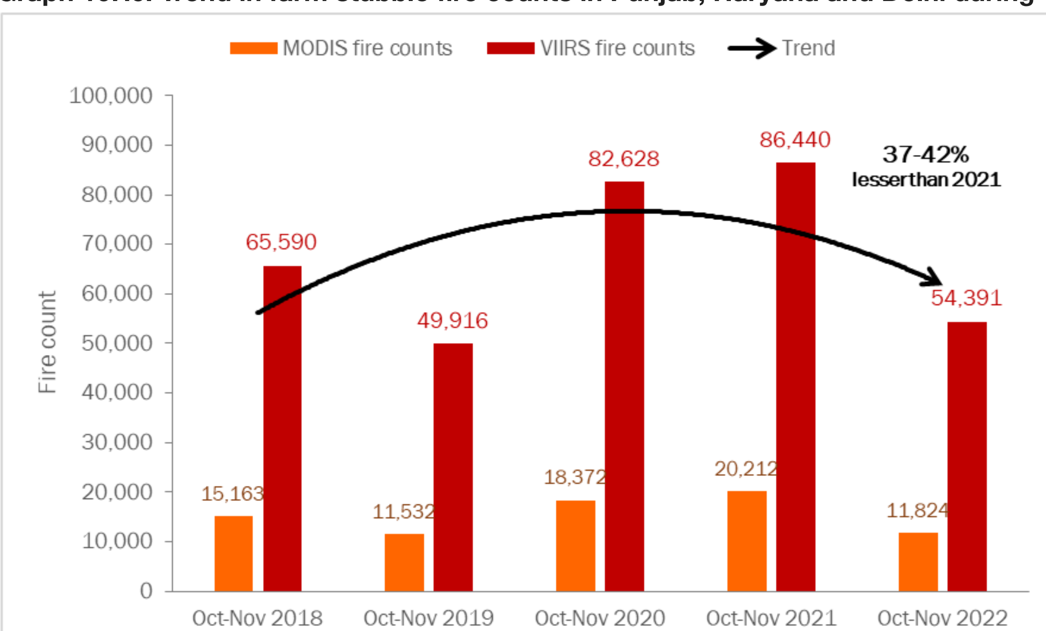
Graph 10R5: Trend in Diwali night pollution in Delhi



Note: Average PM2.5 concentration is based on the mean of 12hr values recorded at Delhi's 37 CAAQM stations (2017 Diwali data is based on a lesser number of stations). Nighttime is 8pm to 8am. Pre-diwali night average is the mean of nighttime levels of seven preceding nights.

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

Graph 10R6: Trend in farm stubble fire counts in Punjab, Haryana and Delhi during Oct-Nov

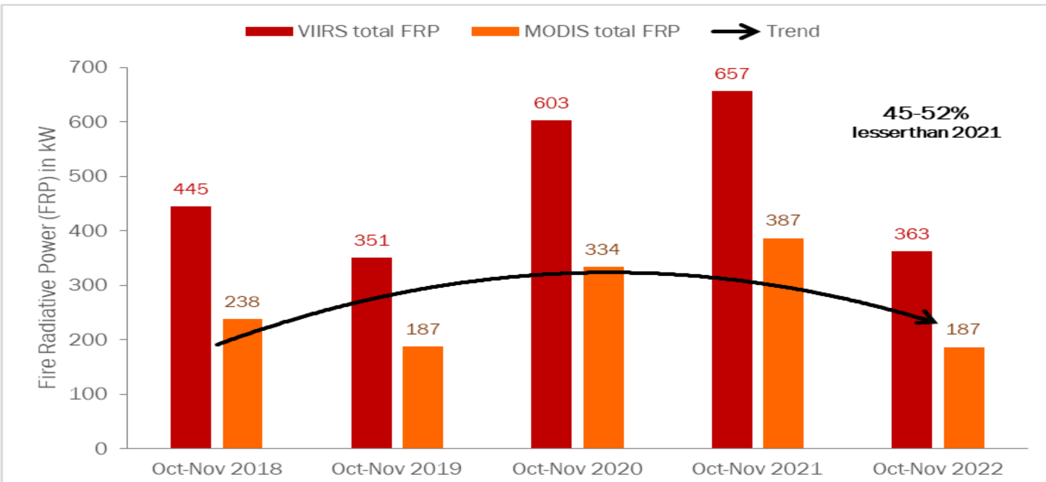


Note: Fire data is based on NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) products. It covers Punjab, Haryana and Delhi. Data up till 30 November 2022.

Source: CSE analysis

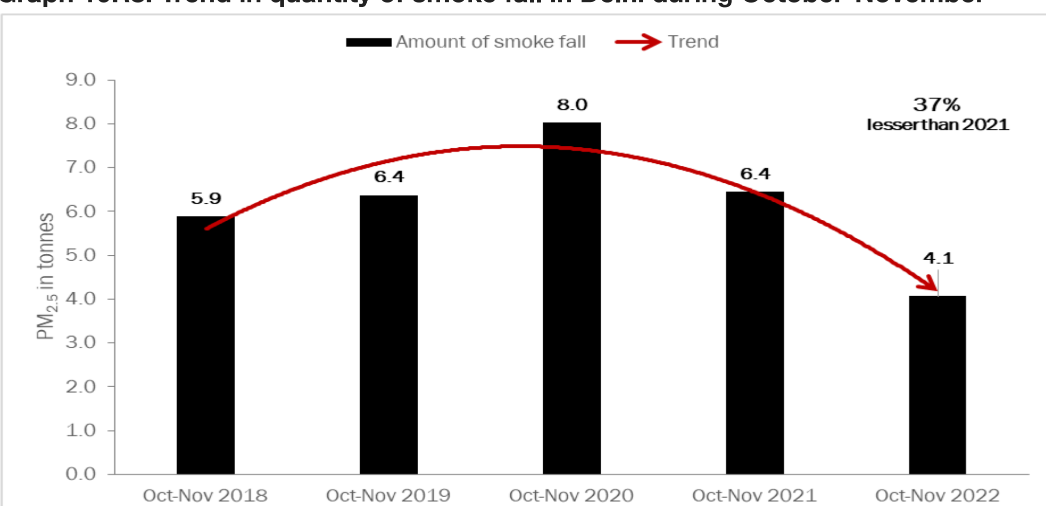
Over 4 tonnes of smoke fell on Delhi, lowest in last five years: The quantity of smoke from farm stubble fires that falls over Delhi is dependent upon two major factors: quantity and intensity of farm stubble fires, and meteorological conditions conducive for transportation of the smoke to Delhi. This October-November not only the quantity and intensity of farm stubble fires have been low but also the meteorological conditions have been less conducive for the transport of the smoke. As a result total smoke that fell upon Delhi in the form of PM2.5 has been considerably lesser. CSE estimated that about 4.1 tonne of PM2.5 fell over Delhi this October-November in from of smoke fall, this is 37 per cent lesser than 6.4 tonne that fell last year and almost half of 2020 figure (See *Graph 10R8: Trend in quantity of smoke fall in Delhi during October-November*). The amount is significantly lower than the 2019 figure as well which is an indicator of meteorological help Delhi got as farm fires in 2019 were lesser.

Graph 10R7: Trend in farm stubble fire power in Punjab, Haryana and Delhi during Oct-Nov



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 a product of average FRP for a day and fire count for that day, done statewise. It covers Punjab, Haryana and Delhi. Data up till 30 November 2022.
Source: CSE analysis

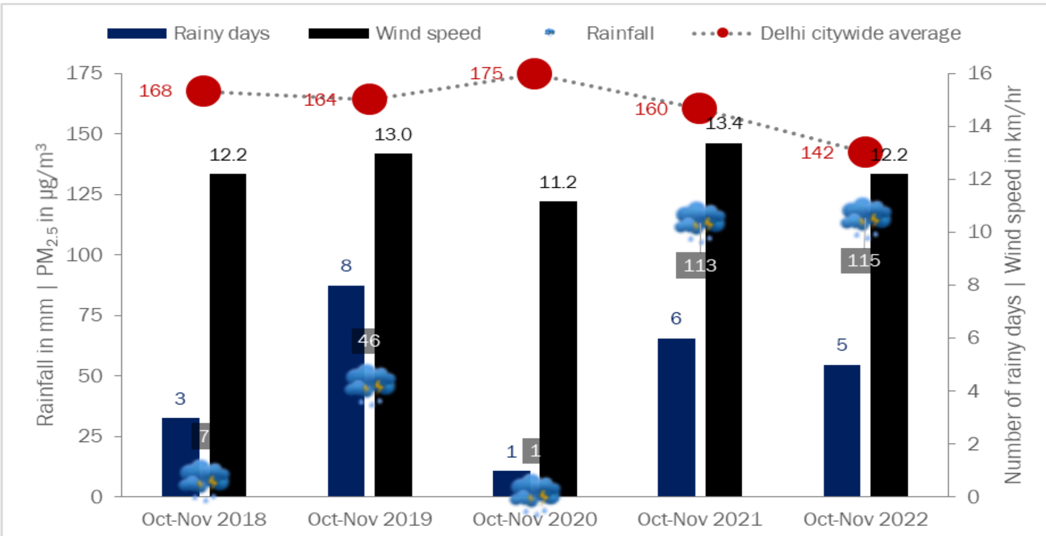
Graph 10R8: Trend in quantity of smoke fall in Delhi during October-November



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 an average of 37 stations of Delhi. The calculation assumes Delhi's geographical area to be 1,483 km^2 and an air slab of 3m from the ground. 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 the last five years. This helped clean-up the city air, especially in the month of October (See *Graph 10R9: 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 10R9: Trend in local meteorological conditions in Delhi during October-November



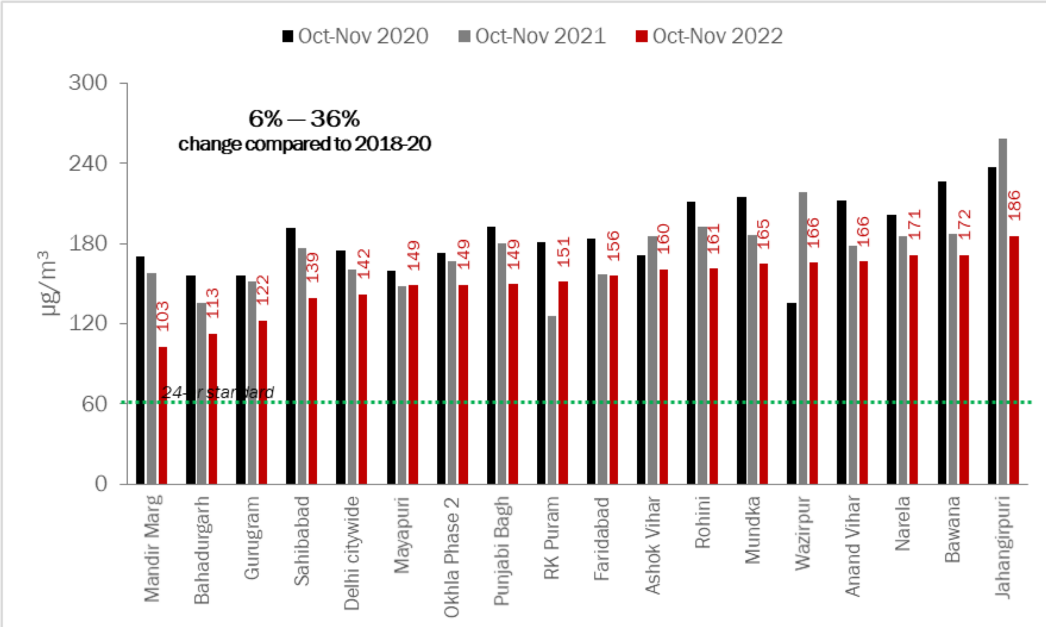
Note: PM2.5 level is based on the mean of 37 stations of Delhi. Rainfall and wind speed data is based on an average of 5 IMD's stations in Delhi.
Source: CSE analysis

Hotspots continue to remain problematic: Hotspots located in North and East Delhi were the most polluted in the city. Jahangirpuri was the most polluted neighbourhood with October-November average PM2.5 level of 186 µg/m^3 (See *Graph 10R10: Trend in October-November PM2.5 level among the official hotspots*). Other most polluted hotspots were Bawana (172 µg/m^3), Nerela (171 µg/m^3), Anand Vihar (166 µg/m^3), Wazirpur (166 µg/m^3), and Mundka (165 µg/m^3). Mandir Marg with 103 µg/m^3 and Bahadurgarh with 113 µg/m^3 were the least polluted among the hotspots.

All hotspots have shown improvement compared to average pollution levels recorded in 2018, 2019 and 2020. Mandir Marg has registered the most improvement with its October-November levels this year being 36 per cent lower than average of 2018, 2019, and 2020 (See *Graph 10R11: 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 Delhi's citywide average of 16 per cent.

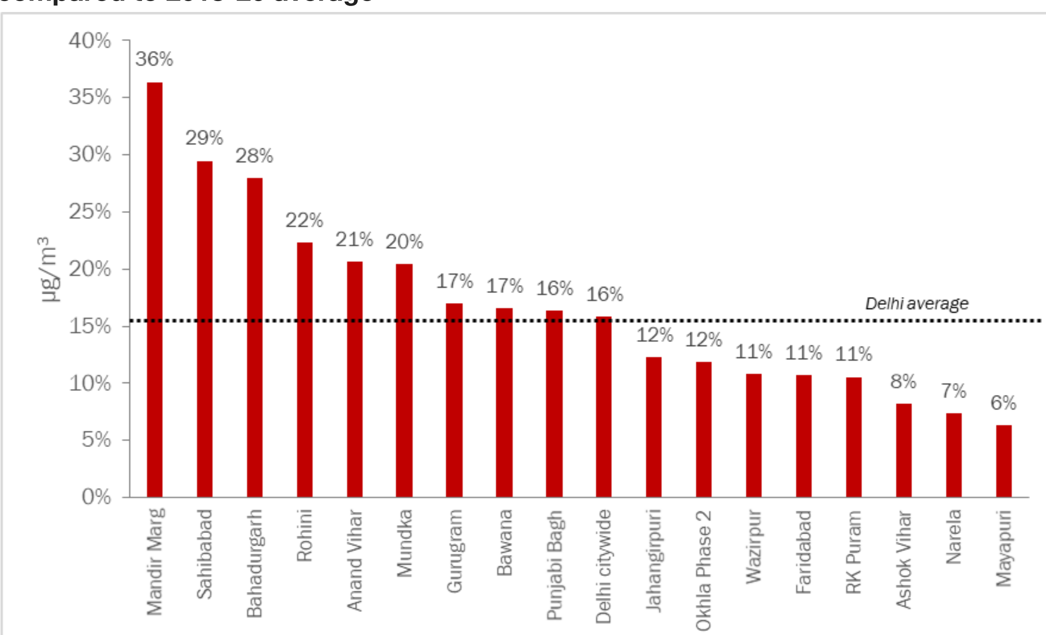
Most polluted locations in NCR continue to be within Delhi's city limits: Burari Crossing has been the most polluted location in NCR with an October-November average of 200 µg/m^3. Jahangirpuri, Nehru Nagar, Vivek Vihar, Bawana, Narela, Alipur, Sonia Vihar, NSIT Dwarka, and Anand Vihar round up the top ten most polluted locations in NCR (See *Annexure 10R: October-November PM2.5 level at station levels among cities of Delhi-NCR*). 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.

Graph 10R10: Trend in October-November PM2.5 level among the official hotspots



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

Graph 10R11: Improvement in October-November PM2.5 level among the official hotspots compared to 2018-20 average



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

Annexure 10R

Oct-Nov PM2.5 level at station levels among cities of Delhi-NCR

	Station	Oct-Nov 2019	Oct-Nov 2020	Oct-Nov 2021	Oct-Nov 2022
1	Burari Crossing, DL	166		164	200
2	Jahangirpuri, DL	179	237	259	186
3	Nehru Nagar, DL	175	193	169	182
4	Vivek Vihar, DL	189	218	201	178
5	Bawana, DL	203	227	188	172
6	Narela, DL	152	202	186	171
7	Alipur, DL	166	197	174	171
8	Sonia Vihar, DL	148	206	182	167
9	NSIT Dwarka, DL	170	85	166	167
10	Anand Vihar, DL	200	212	178	166
11	Wazirpur, DL	200	135	219	166
12	Mundka, DL	191	215	186	165
13	Patparganj, DL	152	196	177	164
14	Rohini, DL	191	212	193	161
15	Ashok Vihar, DL	188	171	185	160
16	Sector 16A, Faridabad, HR	158	183	157	156
17	Shadipur, DL	126	125	133	155
18	Sector 51, Gurugram, HR		195	163	154
19	Sector 11, Faridabad, HR		159	203	154
20	Loni, Ghaziabad, UP	213	234	240	152
21	Sector 62, Noida, UP	181	190	149	151
22	RK Puram, DL	153	181	126	151
23	Punjabi Bagh, DL	172	193	181	149
24	Okhla Phase 2, DL	165	173	167	149
25	National Stadium, DL	146	153	160	149
26	Pusa DPCC, DL	159	160	148	149
27	Dwarka Sector 8, DL	177	185	163	149
28	North Campus DU, DL	179	178	157	147
29	JLN Stadium, DL	164	159	160	146
30	ITO, DL	166	211	171	143
31	Dr KS Shooting Range, DL	162	184	157	142
32	Knowledge Park III, Greater Noida, UP	169	172	150	140
33	Sirifort, DL	171	159	145	139
34	Vasundhara, Ghaziabad, UP	200	192	177	139
35	Sector 116, Noida, UP	174	176	186	135
36	Dharuhera, HR	114	153	110	134
37	Gwal Pahari, Gurugram, HR	187	140	149	131
38	Sri Aurobindo Marg, DL	148	154	138	131
39	Baghpat, UP	162	186	160	131
40	Najafgarh, DL	146	158	134	128
41	CRRI MathuraRoad, DL	160	165	162	128
42	Teri Gram, Gurugram, HR		143	144	128

	Station	Oct-Nov 2019	Oct-Nov 2020	Oct-Nov 2021	Oct-Nov 2022
43	IGI Airport T3, DL	150	151	133	124
44	Jind, HR	155	179	150	122
45	Vikas Sadan, Gurugram, HR	122	156	151	122
46	Pusa IMD, DL	141	163	138	122
47	Jaibhimnagar, Meerut, UP	146	176	151	119
48	Indirapuram, Ghaziabad, UP	187	204	167	118
49	IHBAS, DL	139	156	157	116
50	Ganganagar, Meerut, UP	152	136	143	116
51	New Industrial Town, Faridabad, HR		157	130	114
52	Sanjay Nagar, Ghaziabad, UP	215	192	170	113
53	Aya Nagar, DL	142	145	124	113
54	Bahadurgarh, HR	103	156	136	113
55	Knowledge Park V, Greater Noida, UP	172	179	149	112
56	Muzaffarnagar, UP	131	138	127	109
57	Manesar, HR	120	138	147	108
58	Sector 1, Noida, UP	191	176	156	108
59	Lodhi Road, DL	144	116	134	107
60	Pallavpuram, Meerut, UP	177	163	160	105
61	Mandir Marg, DL	156	170	158	103
62	Bulandshahr, UP	128	184	145	102
63	Charkhi Dadri, HR		167	137	102
64	Bhiwani, HR	118	48	109	98
65	Bhiwadi, RJ	119	178	149	97
66	DTU, DL	183	209	178	97
67	Rohtak, HR	122	144	130	94
68	Sector 30, Faridabad, HR		157	146	91
69	Hapur, UP	115	71	160	90
70	Ballabgarh, HR	106	123	146	88
71	Sonipat, HR	67	88	96	84
72	Karnal, HR	129	108	103	78
73	Narnaul, HR	90	83	89	66
74	Panipat, HR	160	96	89	57
75	Alwar, RJ	41	55	53	47
76	Palwal, HR	132	55	53	34
77	Mandikhera, HR	111	92	73	27
78	Sector 125, Noida, UP*	177	180	155	41
79	EastArjunNagar, DL*				
80	Chandni Chowk IITM, , DL*		152	119	
81	Lodhi Road IITM, DL*		106	126	

Note: October-November average is based on mean of daily averages. All values are in µg/m^3. *Stations with no or suspect data.
Source: CSE analysis of CPCB realtime data

Report 11

Delhi-NCR: End of winter air pollution analysis

As the winter season comes to a close, an analysis of PM2.5 trends for the period October-January in the Delhi and the National Capital Region (NCR) region conducted by the Urban Lab at the Centre for Science and Environment (CSE) has revealed a continuing drop in seasonal average levels of air pollution, although elevated levels prevailed at city stations. This analysis was conducted to understand the behaviour of winter pollution in the region, and to compare it with the longer term context of seasonal variation and annual trends in particulate pollution.

This analysis of the realtime data from monitoring stations in Delhi-NCR for the winter period (Oct 1- Jan 31), reveals that this winter was the cleanest since large-scale air quality monitoring started in 2018, largely due to heavy and extended rainfall in the early phases of the season. However, there were still 10 days of severe or worse air quality and one four day long smog episode. In the larger NCR, seasonal averages vary considerably among the cities and towns but high pollution episodes are synchronised despite large distances. Delhi and neighbouring cities of Faridabad, Ghaziabad, Gurugram, and Noida are relatively more polluted than other NCR towns but not by significantly.

A comprehensive analysis of the PM2.5 trend during the entire winter season (October-January) in Delhi and National Capital Region (NCR) shows bending of the winter pollution curve and lowering of peak levels. This analysis was conducted to understand the behaviour of winter pollution in the region, and assess the long seasonal trends. The shows that there were still 10 days of severe and severe plus air quality and one four day long smog episode during this winter. In the larger NCR, seasonal averages varied considerably among the cities and towns but high pollution episodes are synchronised despite large distances. Delhi and neighbouring cities of Faridabad, Ghaziabad, Gurugram, and Noida are relatively more polluted than other NCR towns but not by significantly.

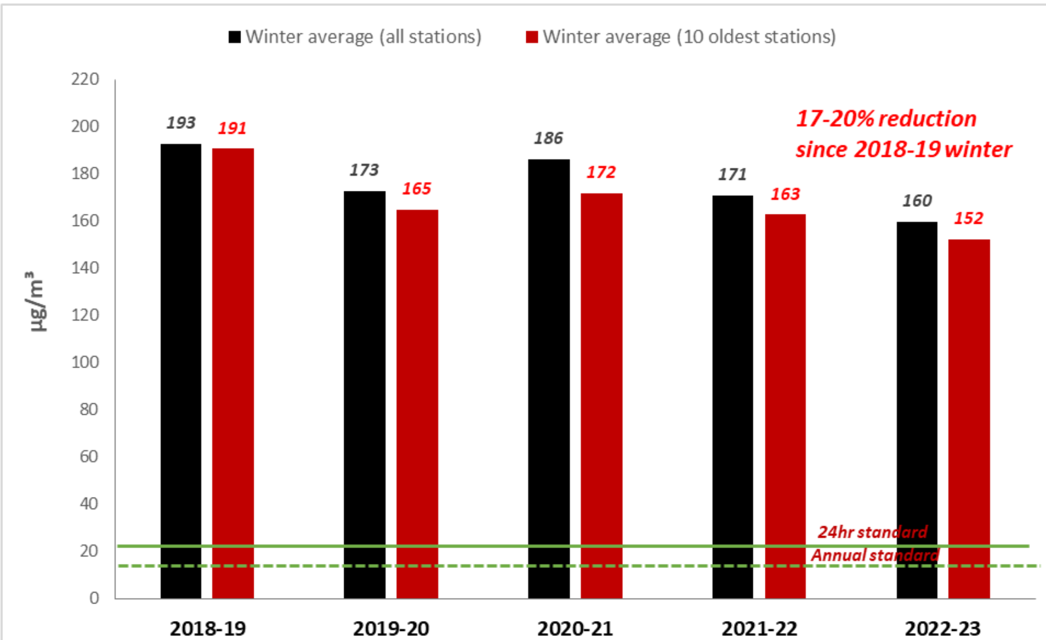
This improvement is a combined effect of meteorology and emergency action based on pollution forecasting. There was heavy and extended rainfall in the early phases of the season that prevented smog episodes from building up and also lowered the seasonal average. Despite the decline, Delhi continues to remain the most polluted among the cities and towns of NCR. This downward trend will have to be sustained with much stronger action on vehicles, industry, waste burning, construction, solid fuel and biomass burning to meet the clean air standard.

Data used in the analysis: This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1 October to 31 January 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 the 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. 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).

Key findings: Delhi

This winter was the least polluted in last five years: The citywide winter average for Delhi stood at 160 µg/m³ for the October – January period which is the lowest level recorded since wide scale monitoring started in 2018-19 *(See Graph 11R1: Trend in average winter pollution in Delhi).* PM2.5 level, computed by averaging monitoring data from 36 CAAQMS stations located in the city, this October-January has been 17 per cent lower compared to seasonal average of 2018-19 winter. Based on the subset of the ten oldest stations, improvement is of almost 20 per cent.

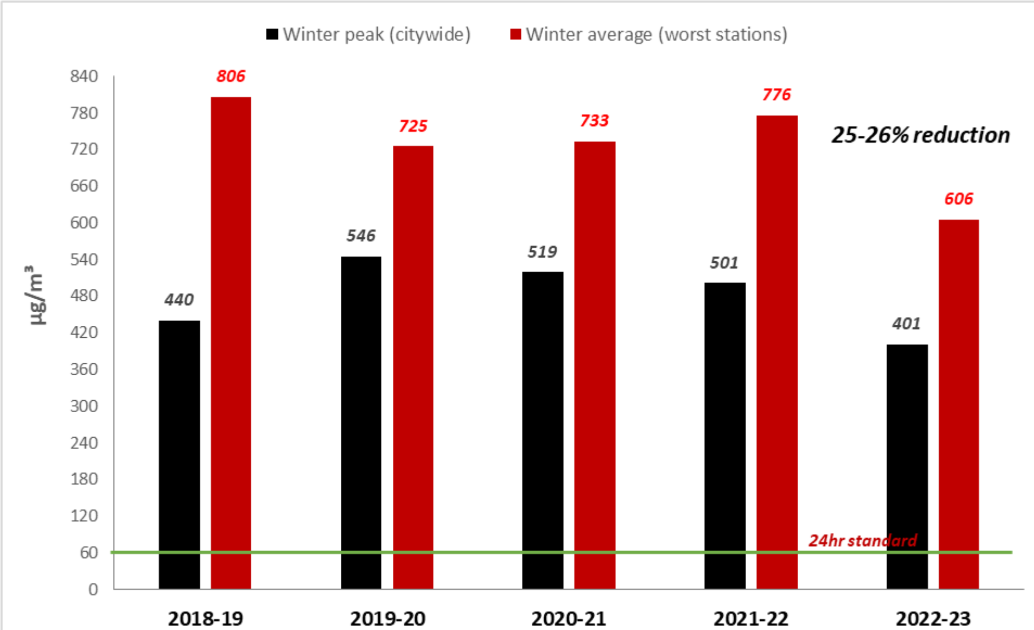
Graph 11R1: Trend in average winter pollution in Delhi



Note: Average PM2.5 concentration is based on the mean of daily values recorded at 36 CAAQMS stations in the city that have adequate data for all winters.
Source: CSE analysis of CPCB's real time air quality data.

Peak pollution level down but still toxic: Like the citywide winter average for Delhi, the winter peak pollution level was found to be the lowest recorded since wide scale monitoring started in 2018-19. The citywide peak this year stood at 401 µg/m³ which was recorded on 3 November 2022 *(See Graph 11R2: Trend in peak winter pollution in Delhi).* Peak PM2.5 24-hour value, computed by averaging monitoring data from 36 CAAQMS stations located in the city, this winter has been 26 per cent lower compared to the highest recorded winter peak (546 µg/m³ in 2019-20 winter). Worst station level peak was 25 per cent lower compared to the highest recorded station level winter peak (806 µg/m³ in 2018-19 winter).

Graph 11R2: Trend in peak winter pollution in Delhi



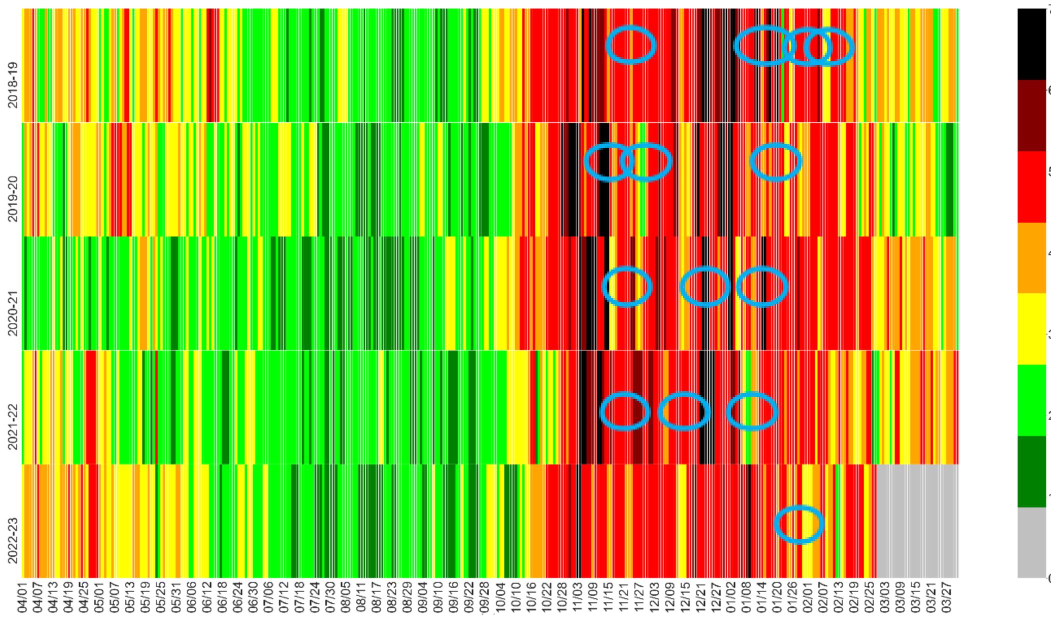
Note: Average PM2.5 concentration is based on the mean of daily values recorded at 36 CAAQMS stations in the city that have adequate data for all winters.
Source: CSE analysis of CPCB's real time air quality data.

Only one smog episode this winter: As is the global practice, at least three continuous days of severe AQI is considered a smog episode. In previous winters such episodes have been recorded lasting 6-10 days. This winter only one smog episode was recorded from 6-9 January (See *Graph 11R3: Air quality calendar of Delhi*). Average daily intensity of this smog stood at 287 µg/m³. This winter was the first in the last five years when both Diwali and late December around Christmas did not experience a smog episode.

Number of days with severe or severe plus air quality was lowest in the last five years: This winter 10 days had citywide average in "severe' or worse AQI category, which is much lower compared to 24 such days in previous winter and 33 days in 2018-19 winter. *(See Graph 11R4: Distribution of October-November days as per AQI category for Delhi).*

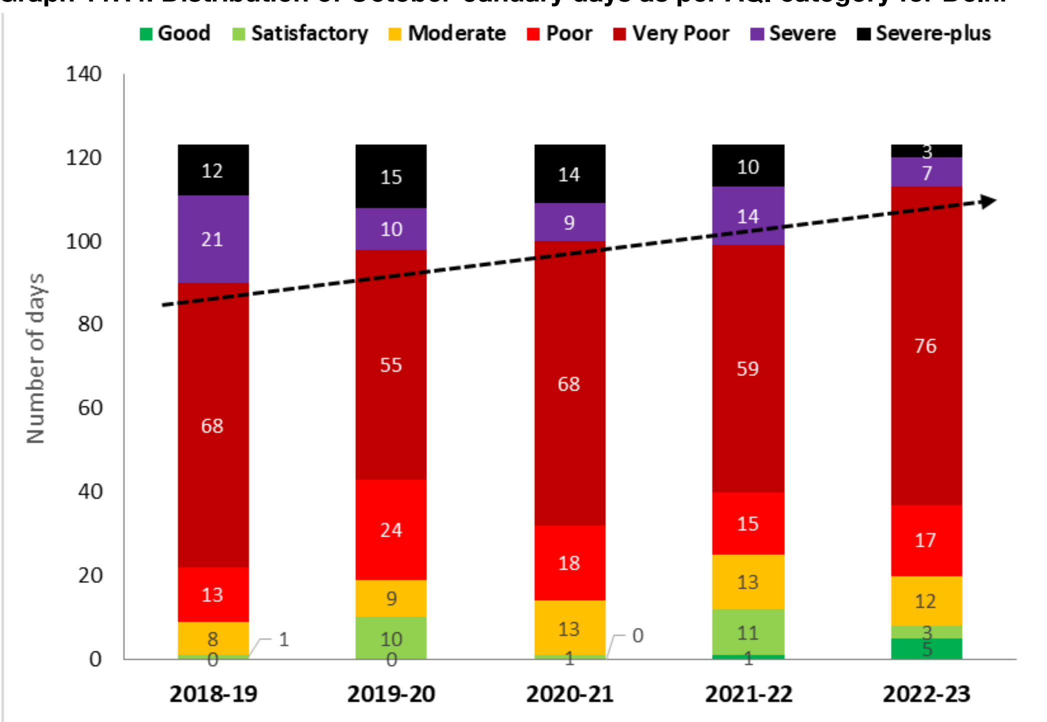
City also recorded five days of good air this year which is an improvement over the previous winter which recorded one "good" AQI day. Among earlier winters when no good air quality days were recorded. All these "good" AQI days this winter coincided with heavy rainfall days in October.

Graph 11R3: Air quality calendar of Delhi



Note: PM2.5 level is based on an average of 37 stations which includes the Delhi stations except Lodhi Road IITM, Chandni Chowk 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

Graph 11R4: Distribution of October-January days as per AQI category for Delhi

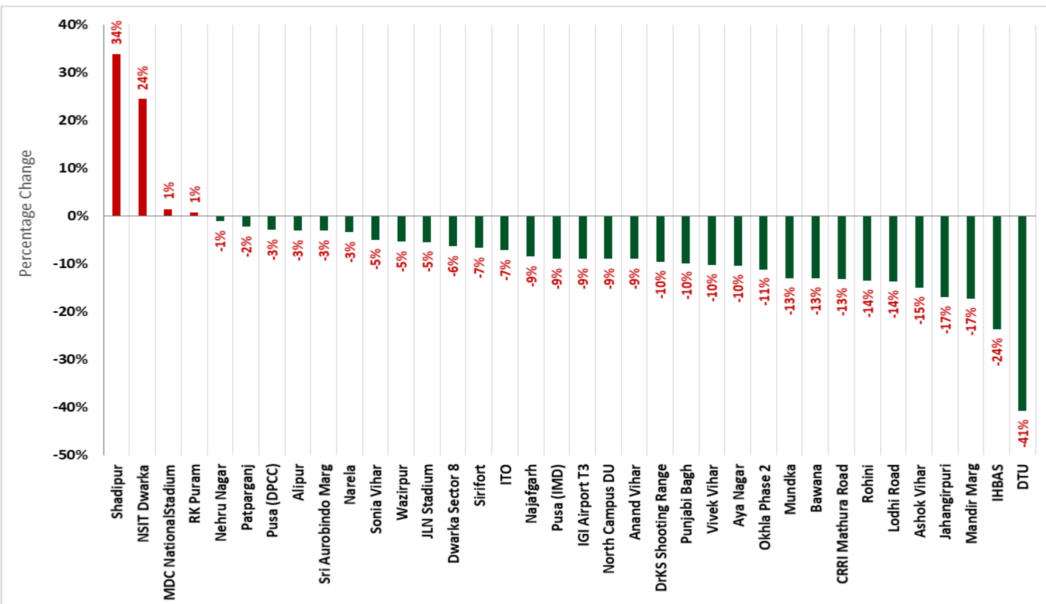


Note: Average PM2.5 concentration is based on the mean of daily values recorded at 36 CAAQMS stations in the city that have adequate data for all four winters.
Source: CSE analysis of CPCB's real time air quality data

Variation in pollution level among city's stations remains significant: This winter, 32 out of 36 CAAQMS stations saw improvement in their seasonal average over last three year average. Most improvement was noted at DTU and IHBAS which registered 41 per cent and 24 per cent lower seasonal average this winter compared to mean of previous three winters respectively. Shadipur (34 per cent), NSIT Dwarka (24 per cent), National Stadium (1 per cent) and RK Puram (1 pre cent) were the three stations that registered increase in seasonal PM2.5 level compared to previous winters (See *Graph 11R5: Change in seasonal PM2.5 level among stations of Delhi compare to the mean of previous three winters*).

Despite improvement this winter, pollution level still remained very high across all stations. The seasonal average ranged between 115 µg/m^3 at IHBAS and 211 µg/m^3 at Nehru Nagar. Jahangirpuri was the second most polluted location in the city with the seasonal average of 201 µg/m^3 (See *Graph 11R6: PM2.5 variation among stations of Delhi*). Peak pollution ranged from 278 µg/m^3 at IHBAS to 606 µg/m^3 at Patparganj.

Graph 11R5: Change in seasonal PM2.5 level among stations of Delhi compare to mean of previous three winters

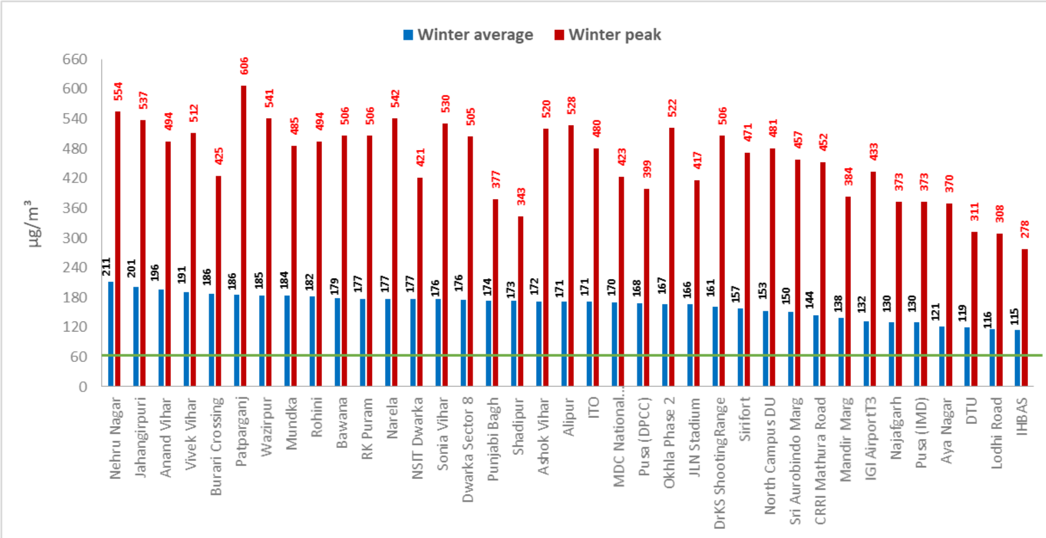


Note: Average PM2.5 concentration is based on the mean of daily values recorded at 36 CAAQMS stations in the city that have adequate data for all three winters.
Source: CSE analysis of CPCB's real time air quality data

Pollution hotspots continue to remain problematic: Hotspots located in North and East Delhi were the most polluted in the city. Jahangirpuri was the most polluted neighbourhood with October-January average PM2.5 level of 201 µg/m^3 *(See Graph 11R7: Trend in October-January PM2.5 level among the official hotspots).* Other most polluted hotspots were Anand Vihar (196 µg/m^3), Wazirpur (185 µg/m^3), Mundka (185µg/m^3), Rohini (182 µg/m^3) and Bawana (179 µg/m^3). Bahadurgarh with 105 µg/m^3, Gurugram and Faridabad each with 133 µg/m^3 were the least polluted among the official hotspots.

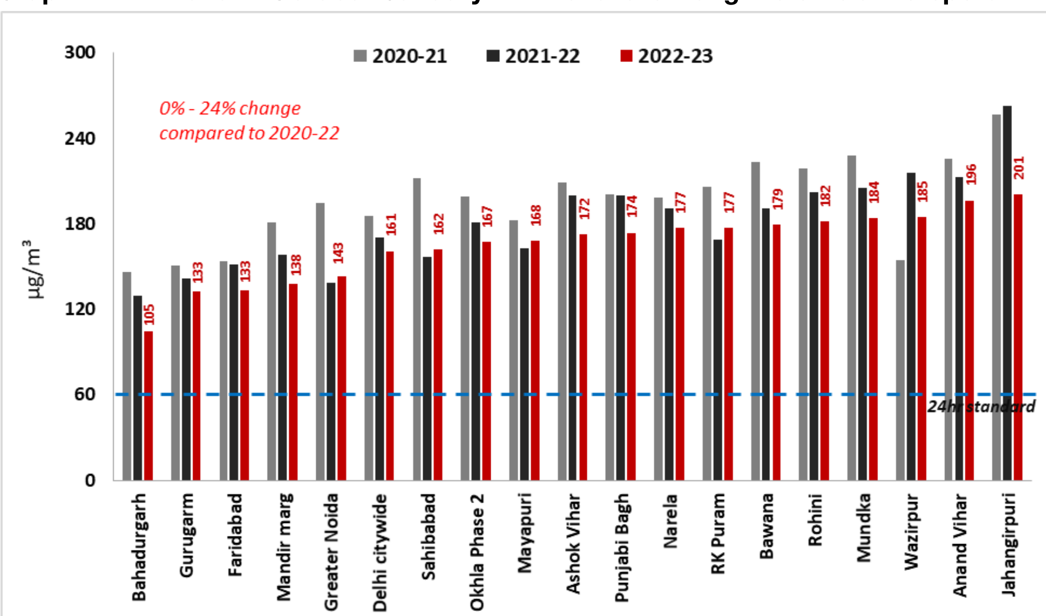
All hotspots have shown improvement compared to average pollution level recorded over previous three winters except RK Puram. Greater Noida has registered the most improvement with its October-January levels this year being 18 per cent lower than average of previous three winters (See *Graph 11R8: Improvement in October-January PM2.5 level among the official hotspots compared to previous three winters*). RK Puram registered 1 per cent increase for the same duration. Wazirpur (5 per cent), Narela (3 per cent), Mayapuri (3 per cent) and Faridabad (3 per cent) registered improvement but it is less than the improvement noted in Delhi's citywide average.

Graph 11R6: PM2.5 variation among stations of Delhi



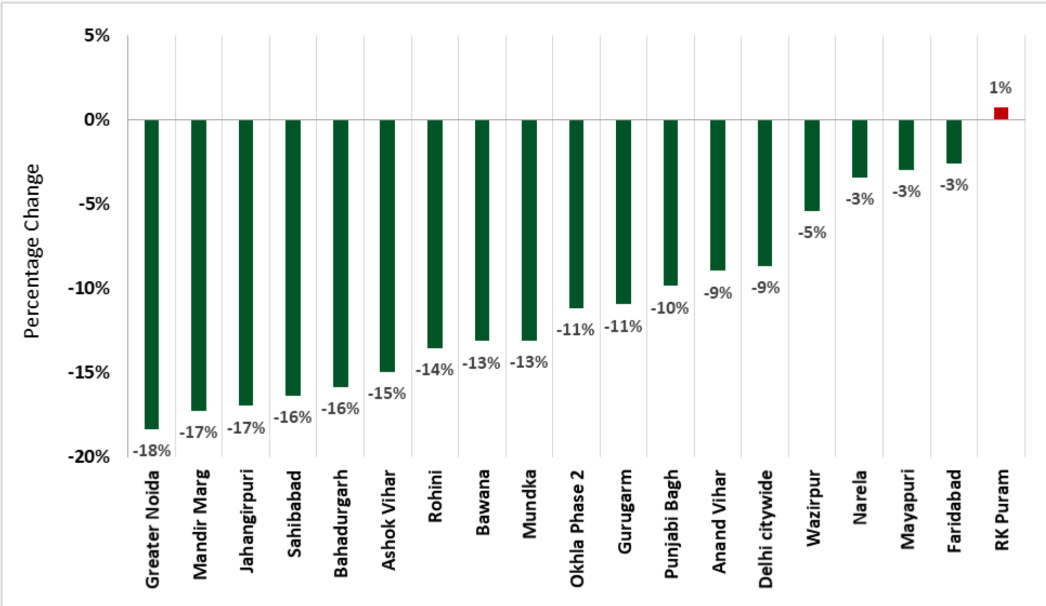
Note: Average PM2.5 concentration is based on the mean of daily values recorded at 36 CAAQMS stations in the city that have adequate data.
Source: CSE analysis of CPCB's real time air quality data

Graph 11R7: Trend in October-January PM2.5 level among the official hotspots



Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for all three winters. Mayapuri and Sahibabad don't have a CAAQM station, therefore the nearest station to them (Pusa DPCC and Vasundhara respectively) is used to represent their air quality.
Source: CSE analysis of CPCB's real time air quality data

Graph 11R8: Improvement in October-January PM2.5 level among the official hotspots compared to previous three winter

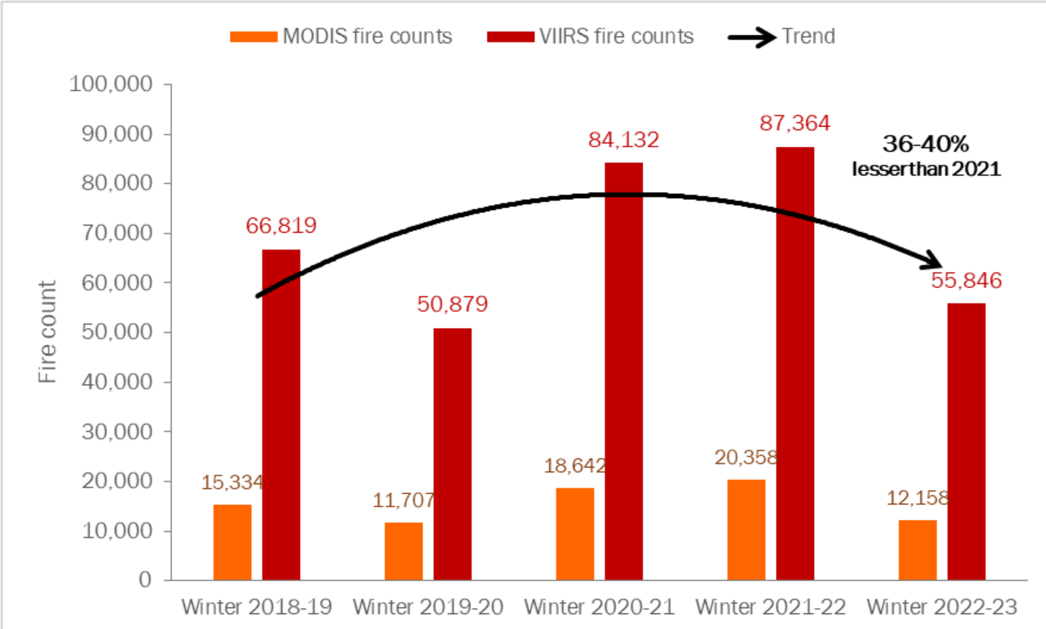


Note: Average PM2.5 concentration is based on the mean of daily values recorded at 36 CAAQMS stations in the city that have adequate data for all three winters.
Source: CSE analysis of CPCB's real time air quality data

Farm stubble fires this winter about half of last winter: The total count of farm stubble fires reported this year from Punjab, Haryana and Delhi in months of October and November stood at 55,846 according to NASA's VIIRS satellite and 12,158 according to NASA's MODIS satellite (See *Graph 11R9: Trend in farm stubble fire counts in Punjab, Haryana and Delhi during October-January*). These are respectively 36 per cent and 40 per cent lower than the figures for October-January of 2021-22. If the FRP (fire radiative power is measure of intensity of fire) is taken into account in addition to the number of fires, it becomes clear that not only were the fires lesser in count but also lesser in intensity compared to previous two years. The total FRP this October-January has been 373 kW and 199 kW according to VIIRS and MODIS respectively (See *Graph 11R10: Trend in farm stubble fire power in Punjab, Haryana and Delhi during October-January*). This is 43 per cent and 49 per cent lower than last year's values of VIIRS and MODIS respectively.

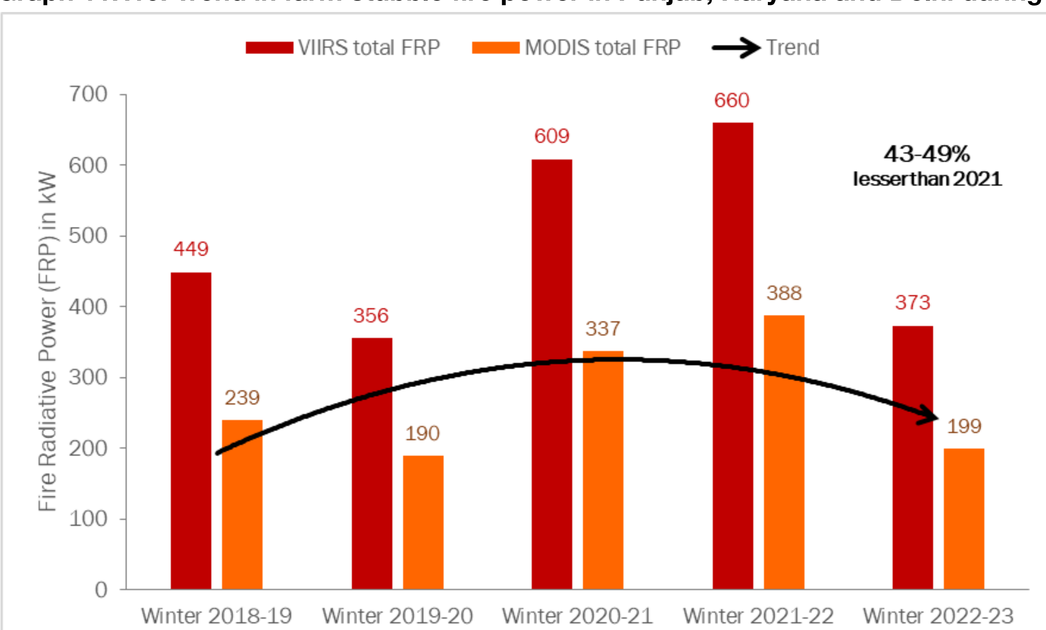
Fires have been lower this October-January both in count and intensity compared to previous two seasons, but are marginally higher compared to the 2019-20 season. Therefore, it can be argued that the spike seen in the fires since pandemic started has ended and the situation has reverted to pre-pandemic scenario. This is a relatively better scenario but still far from clean air objective.

Graph 11R9: Trend in farm stubble fire counts in Punjab, Haryana and Delhi during Oct-Jan



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 31 January 2023.
Source: CSE analysis

Graph 11R10: Trend in farm stubble fire power in Punjab, Haryana and Delhi during Oct-Jan

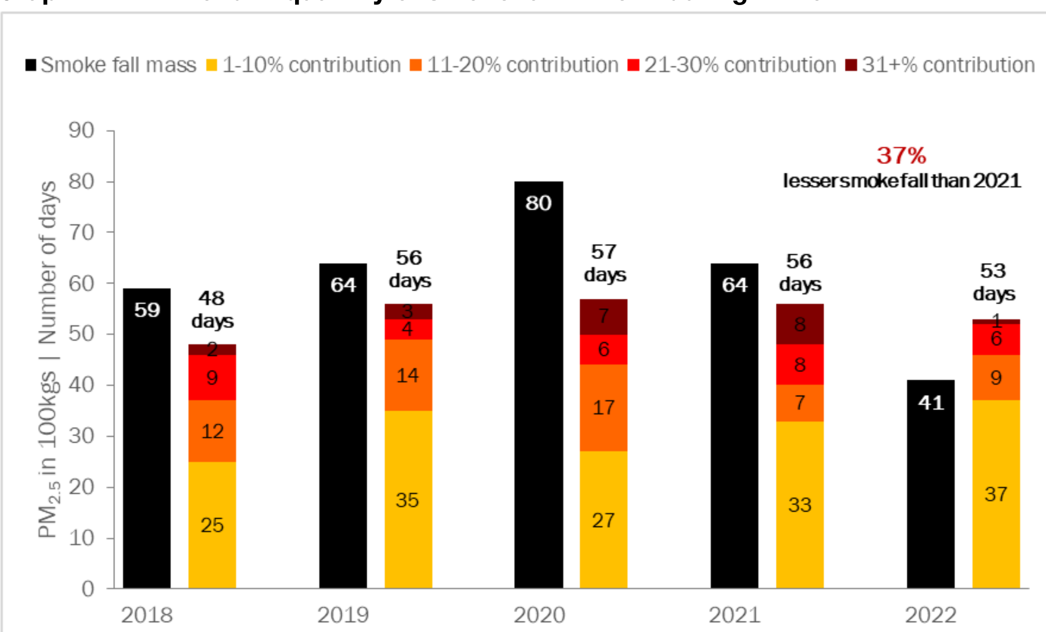


Note: Fire data is based on NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) products. Total FRP is calculated as a product of average FRP for a day and fire count for that day, done state wise. It covers Punjab, Haryana and Delhi. Data up till 31 January 2023.
Source: CSE analysis

Over four tonnes of smoke fell on Delhi, lowest in last five years: This year smoke from the farm stubble fires contributed to PM2.5 levels in Delhi in 53 days, starting October 12 and ending on December 3, 2022. This is less than the previous three years when smoke intrusion was reported on 56 days, but it is higher than the 2018-19 winter figure of 48 days. Highest contribution this year was 34 per cent and it was reported on November 3, 2022. But given the overall low PM2.5 levels this year, 34 per cent contribution accounts for much less in terms of actual PM2.5 concentration in 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 winter not only has the quantity and intensity of farm stubble fires been low but also the meteorological conditions have been less conducive for the transport of the smoke. As a result total smoke that fell upon Delhi in the form of PM2.5 has been considerably lesser. CSE estimated that about 4.1 tonnes of PM2.5 fell over Delhi this winter in the form of smoke fall, this is 37 per cent lesser than 6.4 tonnes that fell last year and almost half of the 2020-21 winter figure (See *Graph 11R11: Trend in quantity of smoke fall in Delhi during winter*).

Graph 11R11: Trend in quantity of smoke fall in Delhi during winter



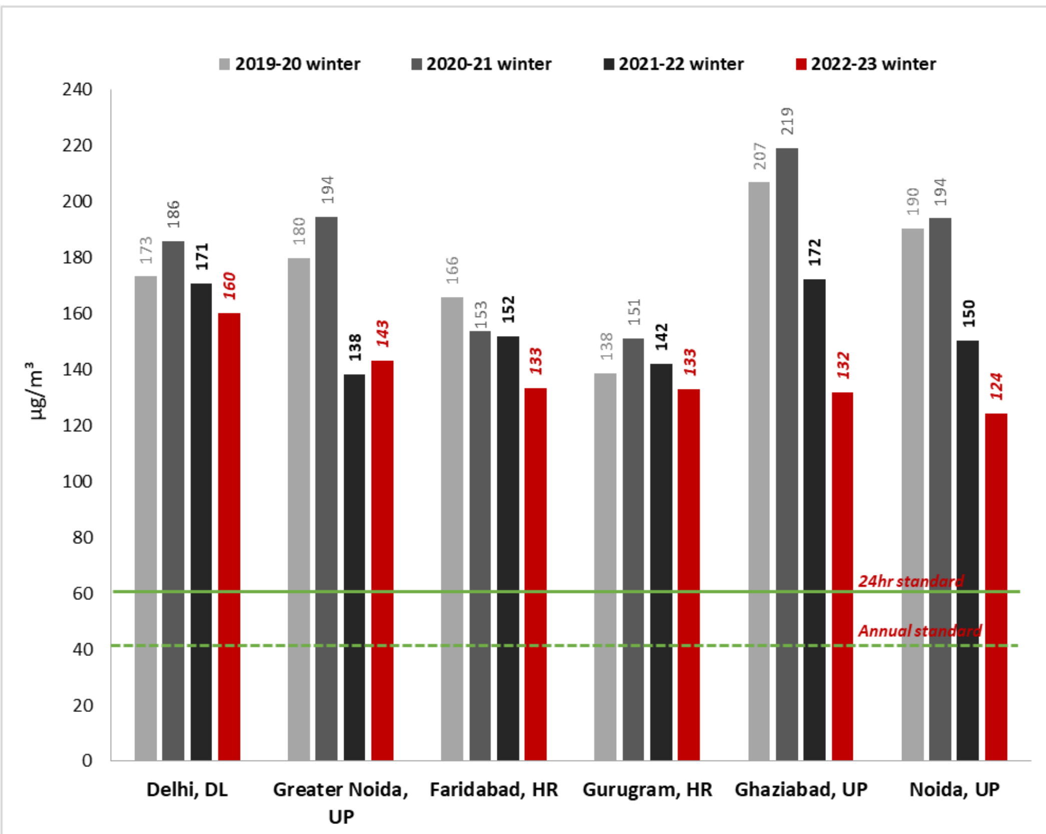
Note: Total smoke fall PM2.5 quantity is calculated using SAFAR India's data on farm stubble fire smoke contribution to Delhi's PM2.5 level and daily PM2.5 concentration data based on an average of 37 stations of Delhi. The calculation assumes Delhi's geographical area to be 1,483 km^2 and air slab of 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 numbers. Data up till 31 January 2023.
Source: CSE analysis

Key findings: National Capital Region (NCR)

Delhi was the most polluted among the five major towns in NCR: In absolute concentration, Delhi was the most polluted major city in NCR with a winter average of 160 µg/m^3. Greater Noida with 143 µg/m^3 was the next most polluted major city in NCR (See *Graph 11R12: Winter pollution in main NCR cities*). Faridabad and Gurugram both registered 133 µg/m^3 while Ghaziabad did marginally better with a winter average of 132 µg/m^3. Noida was the least polluted major city with a winter average of 124 µg/m^3.

Among the five big NCR cities, Ghaziabad registered the highest improvement in its winter PM2.5 level with a reduction of 23 per cent compared to previous winter average. Noida (17 per cent), Faridabad (12 per cent) and Gurugram (6 per cent) also registered improvement in air quality but it worsened for Greater Noida (-3 per cent).

Graph 11R12: Winter pollution trend among major NCR cities



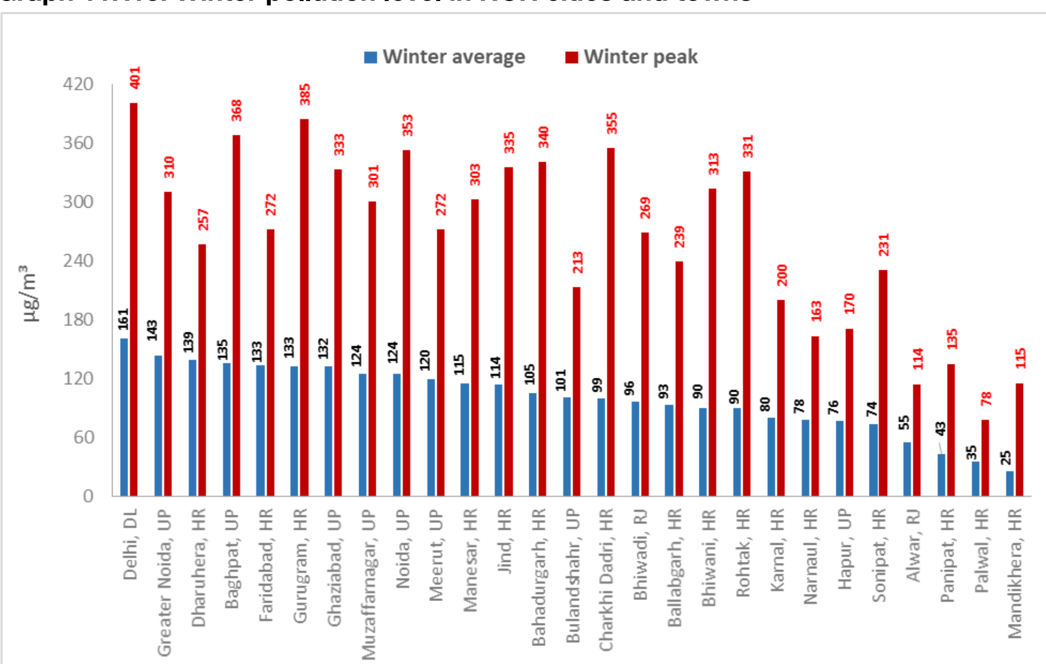
Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for all four winters.
Source: CSE analysis of CPCB's real time air quality data

Big cities of NCR continue to be the most polluted with highest seasonal average and peak pollution levels but smaller towns are not far behind: Delhi was the most polluted city in the NCR followed by Greater Noida, this winter. But Dharuhera and Baghpat, much smaller towns, were next on this worst polluted list, placed above much larger cities of Faridabad, Gurugram and Ghaziabad (See *Graph 11R13: Winter pollution level in NCR cities and towns*). Mandikhera and Palwal were the least polluted towns in the NCR with their winter average settling below 40 µg/m^3. Likewise, Delhi citywide registered the highest peak pollution with 24hr average at 401 µg/m^3 followed by Gurugram at 385 µg/m^3 and Baghpat at 368 µg/m^3. Palwal peak of 78 µg/m^3 was the lowest in the NCR.

Only four out of 25 NCR towns show deterioration in their winter average from the mean of previous three winters. Air quality deteriorated most in Dharuhera in Haryana by 10 per cent with a winter average of 139 µg/m^3. It was followed by Alwar in Rajasthan and Sonipat in Haryana that registered 8 per cent and 4 per cent decline in winter air quality respectively compared to the average of previous three winters. Mandikhera (-70 per cent), Panipat (-60 per cent) and Palwal (-55 per cent) in Haryana registered the most improvement (See *Graph 11R14: Change in seasonal PM2.5 level among NCR cities and towns compared to mean of previous three winters*).

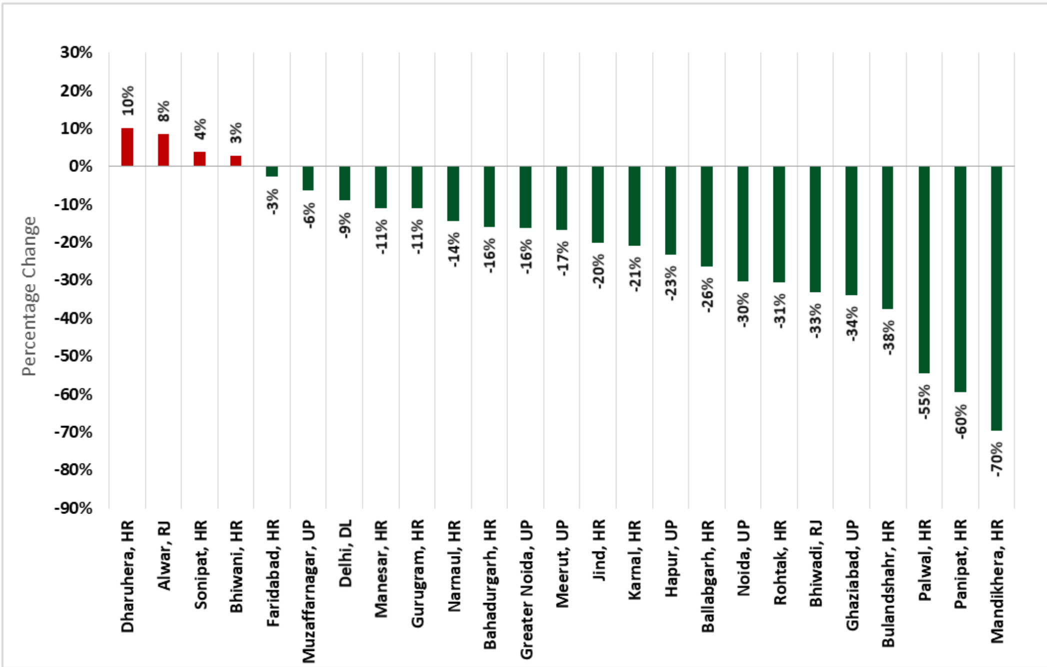
Early winter smog synchronises across the region and is more severe in Delhi and big four: Normally the smog episodes of November are synchronised across the northern region. But it is more intense and lingers longer in Delhi and its immediate neighbouring cities. During winter, the atmospheric changes such as inversion, change in wind direction, and seasonal drop in ambient temperature across North India entraps pollution. Additionally, smoke from farm fires and Diwali firecrackers in November makes the situation even worse. However, the air quality in cities further away from Delhi improves from severe to poor and moderate categories, although Delhi and the big four cities continue to have very poor air quality through the end of January (See *Graph 11R15: PM2.5 calendar for NCR cities and towns*).

Graph 11R13: Winter pollution level in NCR cities and towns



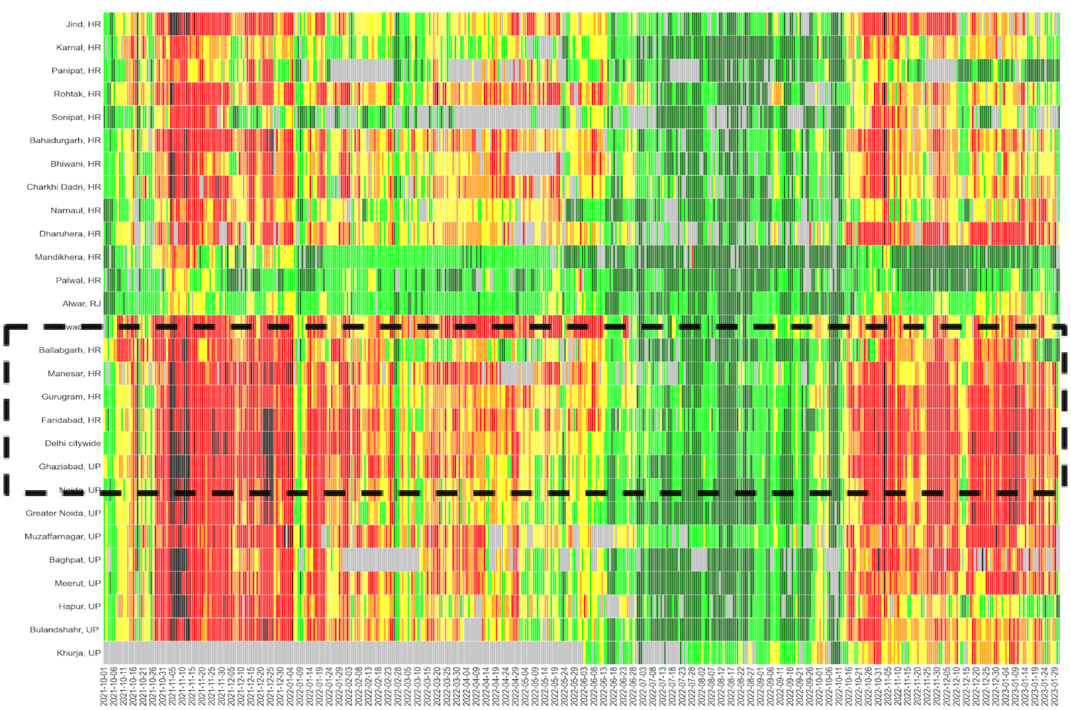
Note: Average PM2.5 concentration is based on the mean of daily values recorded at CAAQM stations in the city that have adequate data for the winter.
Source: CSE analysis of CPCB's real time air quality data

Graph 11R14: Change in seasonal PM2.5 level among NCR cities and towns compared to mean of previous three winters



Note: Average PM2.5 concentration is based on the 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.

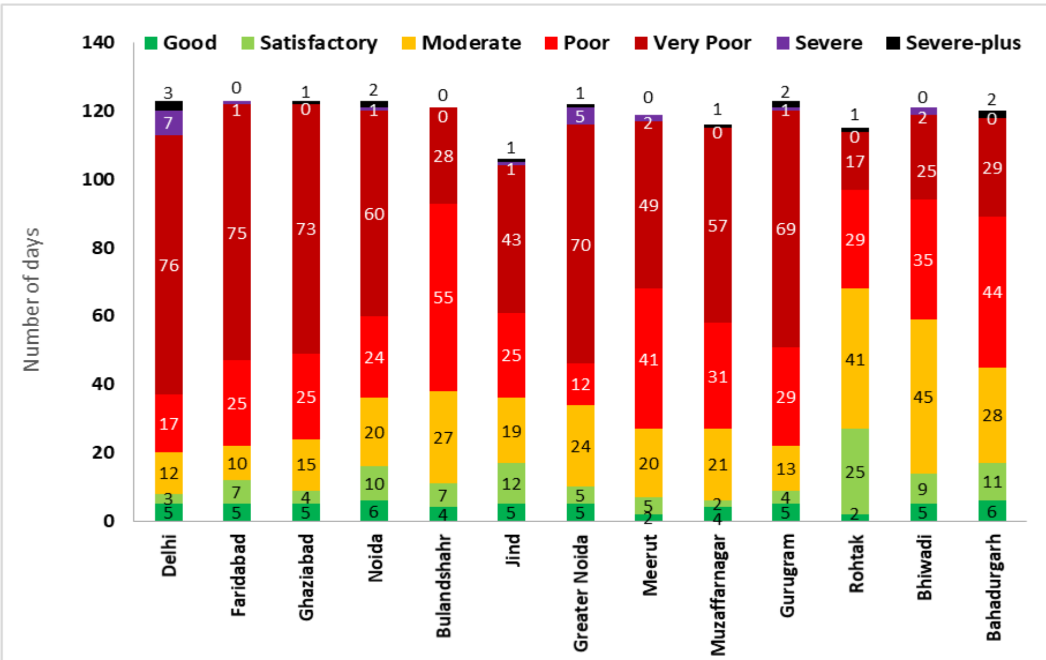
Graph 11R15: PM2.5 calendar for NCR cities and towns



Note: Average PM2.5 concentration is based on the 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.
Source: CSE analysis of CPCB's real time air quality data

Though on a declining trend, Delhi still had the highest number of days in severe or worse air quality categories among the major NCR cities: Although the overall number of days with severe or very poor air quality decreased and stabilised this winter, Delhi still recorded more days with the most severe air quality compared to other major cities in the NCR during the 2022-23 winter. Delhi had 10 days with severe or worse air quality, followed by Greater Noida with 6 days (see *Graph 11R16: Distribution of AQI days for NCR cities and towns*). Noida and Gurugram each had 3 days, and Faridabad and Ghaziabad each had 1 day of severe or worse air quality. Despite the large differences in the number of highly polluted days between the cities, the number of days with good air quality was almost the same across the region. These 2-6 days with good air quality coincided with heavy rainfall and were not the result of on-ground pollution control measures.

Graph 11R16: Distribution of AQI days for NCR cities and towns



Note: Average PM2.5 concentration is based on the 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

Way forward

Winter pollution is the litmus test of clean air action in the region. The only way to prevent the high peaks and smog episodes during winter is to ensure sustained improvement in air quality to meet the national ambient air quality standard. This requires region-wide implementation of:

- Clean fuels and emissions control systems in industry,
- Massive electrification of vehicle fleet,
- Scaling up of integrated public transport options with vehicle restraint measures like parking restraints
- Waste management based on 100% segregation, material recovery and zero landfill policy
- Clean construction and recycling of C&D waste
- Replacement of solid fuels in households
- Urban greening and dust control

Annexure 11R

Winter PM2.5 level at station levels among cities of Delhi-NCR

	Stations	2019-20 winter	2020-21 winter	2021-22 winter	2022-23 winter
1	Nehru Nagar, DL	212	220	209	211
2	Jahangirpuri, DL	206	257	263	201
3	Anand Vihar, DL	209	226	213	196
4	Vivek Vihar, DL	199	234	207	191
5	Burari Crossing, DL	169		141	186
6	Patparganj, DL	164	213	191	186
7	Wazirpur, DL	215	154	216	185
8	Mundka, DL	203	228	205	184
9	Rohini, DL	209	219	202	182
10	Bawana, DL	205	224	190	179
11	RK Puram, DL	154	206	169	177
12	Narela, DL	162	198	191	177
13	NSIT Dwarka, DL	171	94	161	177
14	Sonia Vihar, DL	159	216	183	176
15	Dwarka Sector 8, DL	188	198	176	176
16	Sector 16A Faridabad, HR	166	198	172	174
17	Punjabi Bagh, DL	178	201	200	174
18	Shadipur, DL	147	112	130	173
19	Ashok Vihar, DL	199	209	200	172
20	Alipur, DL	167	197	167	171
21	ITO, DL	172	209	172	171
22	MDC National Stadium, DL	155	173	174	170
23	Pusa DPCC, DL	174	183	163	168
24	Okhla Phase 2, DL	185	199	181	167
25	JLN Stadium, DL	180	179	168	166
26	Sector 62 Noida, UP	184	195	150	165
27	Vasundhara Ghaziabad, UP	213	212	157	162
28	DrKS Shooting Range, DL	175	192	168	161
29	KP III Greater Noida, UP	179	191	143	160
30	Sirifort, DL	180	174	152	157
31	Sector 11 Faridabad, HR		159	189	153
32	North Campus DU, DL	165	179	159	153
33	Sector 51 Gurugram, HR		172	163	152
34	Loni Ghaziabad, UP	213	246	244	152
35	Sri Aurobindo Marg, DL	153	165	146	150
36	Sector 116 Noida, UP	191	202	166	149
37	CRRI Mathura Road, DL	166	178	154	144
38	Dharuhera, HR	109	156	112	139
39	Mandir Marg, DL	161	181	158	138
40	Gwal Pahari Gurugram, HR	166	148	138	136
41	SPIC Baghpat, UP				135
42	Teri Gram Gurugram, HR		125	134	135

	Stations	2019-20 winter	2020-21 winter	2021-22 winter	2022-23 winter
43	Jaibhimnagar Meerut, UP	133	178	147	135
44	IGI Airport T3, DL	149	155	133	132
45	KPV Greater Noida, UP	182	198	140	131
46	Najafgarh, DL	142	152	133	130
47	Pusa IMD, DL	131	159	138	130
48	Ganganagar Meerut, UP	133	149	137	129
49	Vikas Sadan Gurugram, HR	122	158	155	127
50	Muzaffarnagar, UP	128	136	135	124
51	New Industrial Town Faridabad, HR		132	139	123
52	Sector 1 Noida, UP	208	197	158	123
53	Aya Nagar, DL	139	145	121	121
54	DTU, DL	193	220	189	119
55	Sanjay Nagar Ghaziabad, UP	205	198	159	117
56	Indirapuram Ghaziabad, UP	199	221	153	116
57	Lodhi Road, DL	140	133	130	116
58	Manesar, HR	106	125	156	115
59	IHBAS, DL	146	154	152	115
60	Jind, HR	132	156	139	114
61	Sector 30 Faridabad, HR		153	151	112
62	Pallavpuram Meerut, UP	160	160	148	111
63	Bahadurgarh, HR	98	146	130	105
64	Bulandshahr, UP	148	196	143	101
65	Charkhi Dadri, HR		129	122	99
66	Bhiwadi, RJ	128	167	137	96
67	Ballabgarh, HR	131	109	138	93
68	Bhiwani, HR	112	44	107	90
69	Rohtak, HR	116	149	123	90
70	Karnal, HR	117	97	88	80
71	Narnaul, HR	89	95	89	78
72	Hapur, UP	86	63	148	76
73	Sonipat, HR	52	88	73	74
74	Sector 125 Noida, UP	180	193	144	63
75	Alwar, RJ	43	55	53	55
76	Panipat, HR	136	97	87	43
77	Palwal, HR	133	53	43	35
78	Mandikhera, HR	100	83	61	25
79	New Collectorate Baghpat, UP	162	176	142	
80	Lodhi Road IITM, DL*		133	160	285
81	Chandni Chowk IITM, DL*		153	120	124
82	East Arjun Nagar, DL*				

Note: October-January average of a city is based on the mean of daily PM2.5 values recorded at CAAQM stations in the city that have adequate data for all winters. Winter is defined as 1 October-28 February.
Source: CSE analysis of CPCB's real time air quality data.