Respirer Living Sciences

CLIMATE TRENDS

Air quality trends in India's most and least polluted cities as peak pollution season starts

#AirPollutionRanking #RespirerReports

Findings

- A list of the 10 most polluted cities in the last year shows that Delhi and other cities in the National Capital Region (NCR) still dominate air pollution rankings.
- Delhi's air quality improved marginally, yet it was the most polluted city between 1 October 2022 and 30 September 2023, with a $PM_{2.5}$ concentration of 100.1 micrograms/cubic metre ($\mu g/m^3$). This is more than thrice the government's 'good' level and 20 times the WHO's safe limit.
- Patna, though in second place at 99.7 $\mu g/m^3$, saw a 24 per cent deterioration in air quality over the previous year.
- Seven cities in the top 10 are in Delhi-NCR and Bihar, both part of the Indo-Gangetic Plain.
- Aizwal, Mizoram, is the place with India's cleanest air, with a $PM_{2.5}$ level of only 11.1 $\mu g/m^3$.
- A look at six major capitals, which have air quality challenges, during the peak pollution months (October–March) between 2019 and 2023 shows that Mumbai's AQ worsened steadily while Delhi's and Lucknow's improved.

From October 1 2023, a revised version of Graded Response Action Plan (GRAP), a government air pollution control programme, has come into force in Delhi and 24 nearby districts, collectively known as the National Capital Region (NCR). The region has several places which frequently top Indian and global air pollution rankings.

Data for the top 10 polluted cities and six major capitals shows that both annual and quarterly $PM_{2.5}$ levels in *all* these places were higher than the Central Pollution Control Board's 'good' level of 30 $\mu g/m^3$ and WHO's safe guideline of 5 $\mu g/m^3$.

In this report, Respirer Reports, an initiative of Respirer Living Sciences, analyses two sets of air quality data. The first is the government's $PM_{2.5}$ data for the past one year,

i.e., 1 October 2022 to 30 September 2023, to track improvement in air quality over the previous year in NCR and other cities listed in the National Clean Air Programme (NCAP).

The other is $PM_{2.5}$ data during winter, roughly October–March when pollution levels rise. The period of study is from 2019, when NCAP was launched, to 2023 in six major capitals known to have air quality challenges. These are Delhi, Mumbai, Kolkata, Bengaluru, Lucknow and Patna.

$PM_{2.5}$ (fine particulate matter) data is a widely used measure for assessing the impacts of air pollution on health. The data is available through NCAP, which aims to reduce $PM_{2.5}$ and PM_{10} concentrations in Indian cities by 40 per cent of 2017 levels by 2026.

$PM_{2.5}$ refers to air particles that are 2.5 microns in diameter, which is approximately $1/30^{th}$ the width of a strand of human hair. It consists of fine, toxic particles that can penetrate deep into the lungs, enter the bloodstream and cause heart disease, stroke and other respiratory diseases.

Delhi tops India's most polluted cities list, followed by Patna and Muzaffarpur

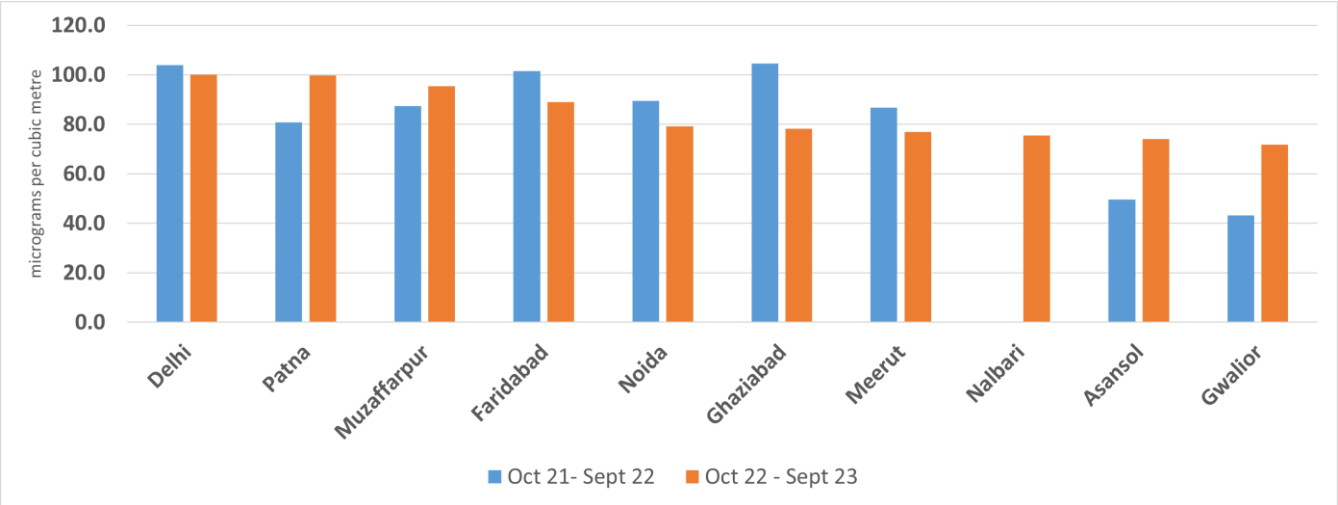
Two regions dominate the top 10 list of polluted cities in India from 1 October 2022 to 30 September 2023 – Delhi-NCR and Bihar. There are five NCR cities, Delhi, Faridabad, Ghaziabad, Noida and Meerut, and in Bihar, Patna and Muzaffarpur. The list also has Nalbari in Assam, Asansol in West Bengal, and Gwalior in Madhya Pradesh. Currently, Nalbari and Asansol have only one air quality monitor each, while Gwalior has three monitors that record the NCAP data. Since NCAP's launch in January 2019, the government has consistently added Continuous Ambient Air Quality Monitoring Stations (CAAQMS), from about 200 then to 517 currently. More measurement can lead to more hyperlocal insights, ultimately leading to improvements in city-level and airshed-level air quality.

Between 1 October 2022 and 30 September 2023, Delhi recorded the highest $PM_{2.5}$ levels in the country at 100.1 $\mu g/m^3$, which is 3.3 times the CPCB's 'good' level and 20 times the WHO's safe limit. Delhi saw a 4 per cent improvement in air quality over the previous year, but Patna, in second place, witnessed a 24 per cent deterioration in air quality.

What explains this sudden rise of $PM_{2.5}$ levels in Patna? It has six air quality monitors – one, in the Muradpur area near the Ganga, recorded an 86 per cent increase in levels over the previous year and another, in the Samanpura area, showed a 53.5 per cent increase. The data from these two monitors is likely to have spiked up the city's levels; a closer, on-ground study may yield more.

Air pollution also shot up in Asansol, West Bengal, by 49 per cent compared to a year earlier. The city's only monitor in the Asansol Court area had a $PM_{2.5}$ concentration of 74 µg/m^3 – 2.4 times the CPCB's safe limit and almost 15 times the WHO's safe limit.

India's Top 10 Polluted Cities in the Last Year, October–September 2022-23



$PM_{2.5}$ levels decreased in the NCR cities of Delhi, Faridabad, Noida, Ghaziabad, and Meerut but increased in Patna, Muzaffarpur, Asansol and Gwalior over the previous year

Rank*	City	State	Oct 2021 – Sept 2022	Oct 2022 – Sept 2023	% Change
1	Delhi	Delhi	103.9	100.1	-4%
2	Patna	Bihar	80.7	99.7	24%
3	Muzaffarpur	Bihar	87.4	95.4	9%
4	Faridabad	Haryana	101.5	89	-12%
5	Noida	Uttar Pradesh	89.5	79.1	-12%
6	Ghaziabad	Uttar Pradesh	104.6	78.3	-25%
7	Meerut	Uttar Pradesh	86.7	76.9	-11%
8	Nalbari	Assam	NA**	75.6	NA
9	Asansol	West Bengal	49.7	74	49%
10	Gwalior	Madhya Pradesh	43.1	71.8	66%

**Annual ranking of NCAP cities based on $PM_{2.5}$ levels. Monitors recorded data for >70 per cent of the time for Oct 2022–Sept 2023. **Data not available*

Apart from Delhi, the other NCR cities in the top 10 showed significant improvement in air pollution during this period – Ghaziabad by 25 per cent, Faridabad and Noida by 12 per cent each, and Meerut 11 per cent. In Ghaziabad in particular, the levels dropped significantly at two monitors in the residential areas of Sanjay Nagar and Indirapuram, by 22.7 per cent and 31.4 per cent, respectively. Although Gwalior recorded a dramatic 66 per cent rise in $PM_{2.5}$ levels in 2022-23, this huge figure may be the skewed result of missing data. Between October 2021 to September 2022, two of the city's four monitors functioned for just about one day in the year, thus recording a low – and inaccurate – annual average of 43.1 $\mu g/m^3$. However, during the same period in 2022-23, three of the city's four monitors recorded data more than 70 per cent of the time to give a higher average of 71.8 $\mu g/m^3$.

Peak pollution months: $PM_{2.5}$ fell in all NCR cities in the top 10 list

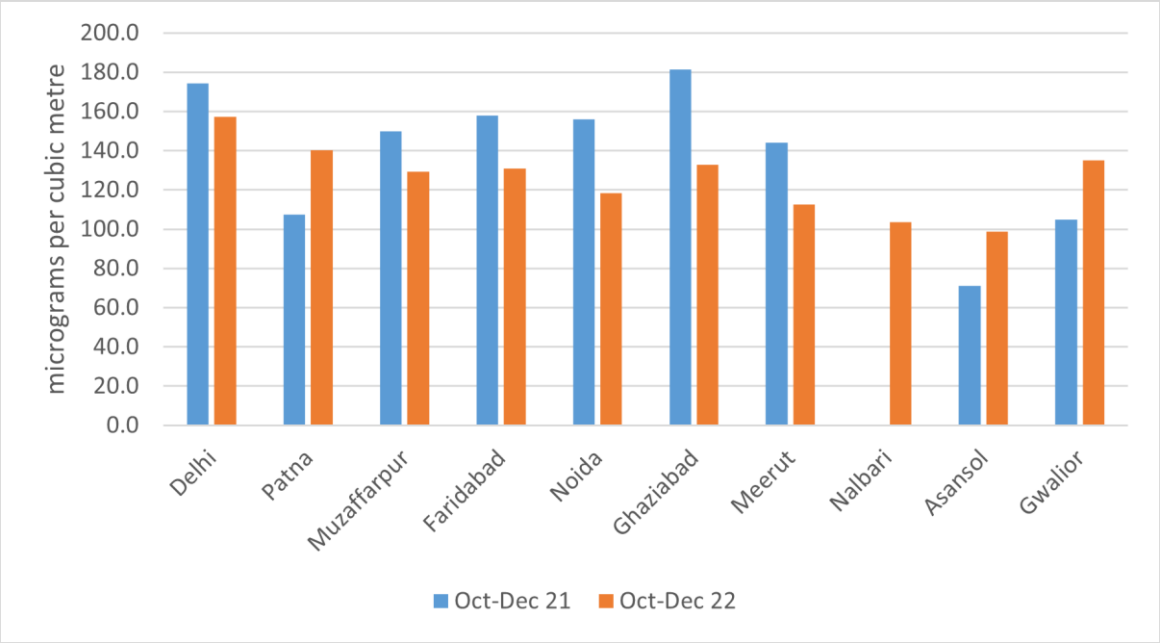
The report splits this period into two quarters: October–December, usually *the* most polluted time of year, and January–March. Pollution in cities like Delhi is highest during the winter months – October–March – because of several factors like cooler temperatures, low or no rainfall, stubble burning, and the bursting of firecrackers.

In the peak pollution months of October–December 2022, $PM_{2.5}$ levels dropped in six of the top 10 cities – Delhi, Faridabad, Noida, Ghaziabad and Meerut in NCR and Muzaffarpur in Bihar – indicating an improvement in air quality compared to the previous year. How much of this was due to climatic factors (rain, wind) and how much due to policy intervention is a matter of deeper study.

The $PM_{2.5}$ levels fell in Delhi by 10 per cent, in Faridabad by 17 per cent, in Noida by 24 per cent, in Ghaziabad by 27 per cent, in Meerut by 22 per cent, and in Muzaffarpur by 14 per cent. By contrast, the $PM_{2.5}$ levels went up in three cities – Patna by 31 percent, Asansol by 39 per cent and Gwalior by 29 per cent – signalling a significant worsening of air quality.

However, despite the decline, the absolute $PM_{2.5}$ levels in all these places was very high posing serious health risks. In Delhi it averaged 157.1 $\mu g/m^3$, well above both the CPCB and WHO's 'safe' limits.

India's Top 10 Polluted Cities during October–December 2022, the peak pollution months



$PM_{2.5}$ levels decreased in Delhi, Faridabad, Ghaziabad, Noida, Meerut and Muzaffarpur but increased in Patna, Asansol and Gwalior

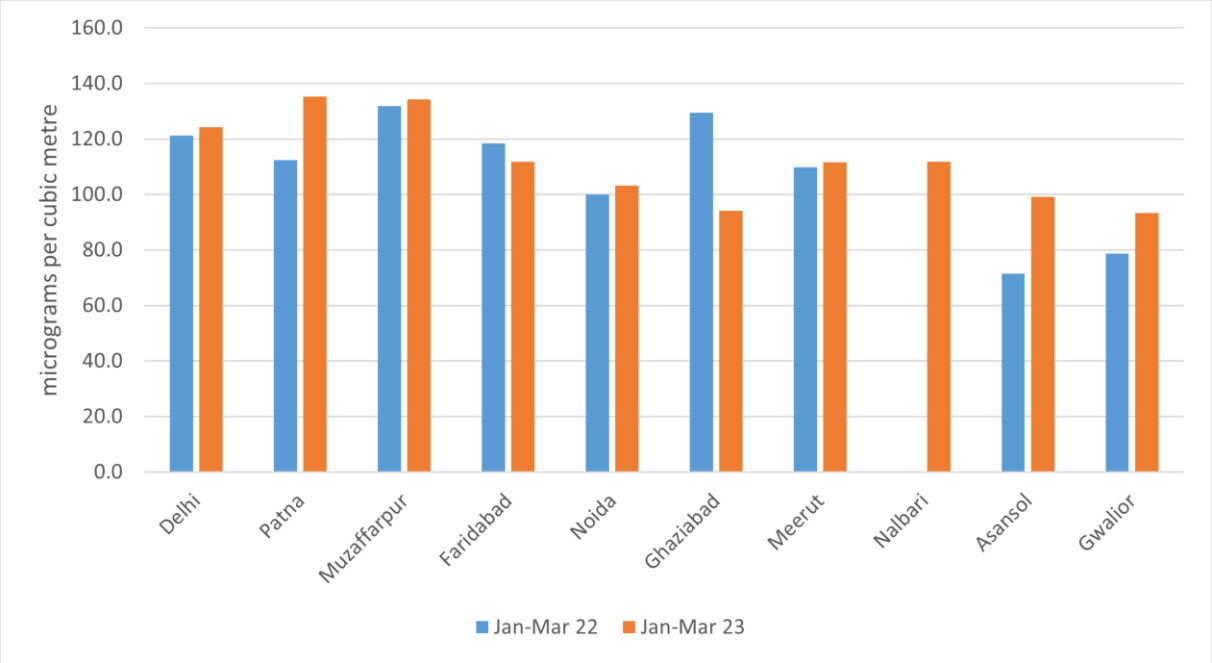
Rank*	City	State	Oct-Dec 2021	Oct-Dec 2022	% Change
1	Delhi	Delhi	174.4	157.1	-10%
2	Patna	Bihar	107.4	140.4	31%
3	Muzaffarpur	Bihar	149.9	129.2	-14%
4	Faridabad	Haryana	157.8	130.9	-17%
5	Noida	Uttar Pradesh	156	118.3	-24%
6	Ghaziabad	Uttar Pradesh	181.3	133.0	-27%
7	Meerut	Uttar Pradesh	144.1	112.7	-22%
8	Nalbari	Assam	NA**	103.5	NA
9	Asansol	West Bengal	71	98.8	39%
10	Gwalior	Madhya Pradesh	104.7	135.0	29%

**Annual ranking of NCAP cities based on $PM_{2.5}$ levels.*
***Data not available*

Air pollution this year: $PM_{2.5}$ rose in Delhi, Patna and other places in January–March

In sharp contrast to the dipping trends in the peak pollution months of October to December, $PM_{2.5}$ levels increased in *seven* of the top 10 cities during January to March 2023– Delhi, Noida and Meerut in NCR, Patna and Muzaffarpur in Bihar, Asansol in West Bengal, and Gwalior in M.P. – indicating a deterioration in air quality compared a year earlier.

India's Top 10 Polluted Cities, January–March 2023



$PM_{2.5}$ levels increased in Delhi, Patna, Muzaffarpur, Noida, Meerut, Asansol and Gwalior but fell in Faridabad and Ghaziabad

Rank*	City	State	Jan-Mar 2022	Jan-Mar 2023	% Change
1	Delhi	Delhi	121.2	124.2	2%
2	Patna	Bihar	112.4	135.2	20%
3	Muzaffarpur	Bihar	131.8	134.3	2%
4	Faridabad	Haryana	118.5	111.8	-6%
5	Noida	Uttar Pradesh	100.1	103.1	3%
6	Ghaziabad	Uttar Pradesh	129.5	94.1	-27%
7	Meerut	Uttar Pradesh	109.8	111.7	2%
8	Nalbari	Assam	NA**	111.8	NA
9	Asansol	West Bengal	71.5	99.1	39%
10	Gwalior	Madhya Pradesh	78.7	93.4	19%

**Annual ranking of NCAP cities based on $PM_{2.5}$ levels.*
***Data not available*

The $PM_{2.5}$ levels went up in Delhi, Meerut and Muzaffarpur by 2 per cent each, and in Noida by 3 per cent. But in three cities they rose at particularly alarming rates: Patna by 20 per cent, Gwalior by 19 per cent and Asansol by 39 per cent. **These three cities showed rising pollution in *both* quarters.** That is, the air quality in these cities deteriorated during the entire peak pollution season of 2022–23 compared to the previous year. The two cities that recorded a drop in $PM_{2.5}$ levels were Faridabad (6 per cent) and Ghaziabad (27 per cent).

Improvement in air quality since the National Clean Air Programme began in 2019?

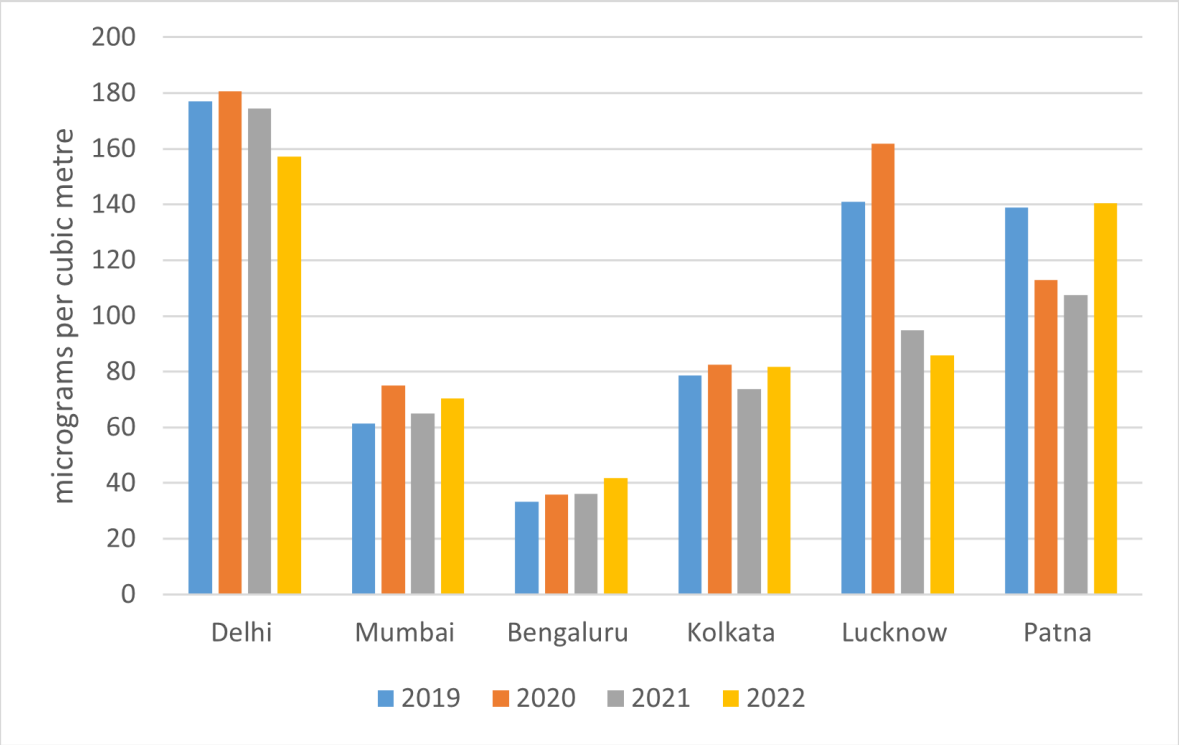
A look at six major capitals

Going back to the start of NCAP to track any long-term improvement in air quality, Respirer Reports analysed $PM_{2.5}$ concentrations in six of India's major capitals facing air pollution challenges – Delhi, Mumbai, Bengaluru, Kolkata, Lucknow and Patna during 2019 to 2023.

Peak pollution months: October to December

For the peak pollution quarter of October–December, Lucknow saw a considerable 32.6 per cent drop between 2019 and 2021 and managed to not only hold on to its gains in air quality but improve further, by 9.4 per cent, in 2022.

Peak pollution months in major capitals, October–December 2022



AQ in Mumbai, Bengaluru and Kolkata deteriorated from 2019 to 2022, but improved in Delhi and Lucknow

City	Oct-Dec 2019	Oct Dec 2020	Oct-Dec 2021	Oct-Dec 2022
Delhi	176.9	180.5	174.4	157.1
Mumbai	61.3	74.9	64.9	70.3
Bengaluru	33.2	36.0	36.0	41.9
Kolkata	78.6	82.4	73.6	81.8
Lucknow	140.9	161.8	94.9	85.9
Patna	138.8	112.9	107.4	140.4

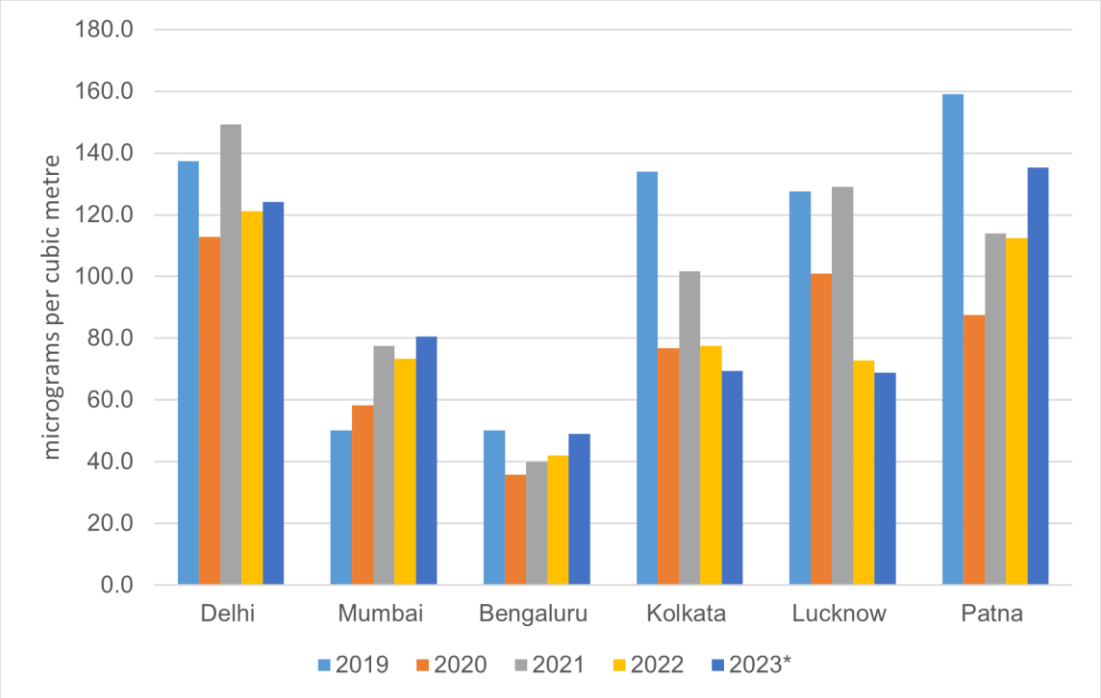
Delhi also showed a steady improvement, by 10 per cent in 2022 over the previous year. However, at an average of over 157.1 µg/m^3 the air quality remained a serious health risk. Patna saw a decreasing trend till 2021 but a sharp rise in 2022. Its 2022 levels were almost the same as those in 2019.

Mumbai, Bengaluru and Kolkata saw levels rise from 2019 to 2022, indicating a deterioration in air quality.

January to March

In the January–March quarter, Mumbai saw a steady deterioration in air quality with $PM_{2.5}$ levels consistently going up from 50.2 µg/m^3 in 2019 to 80.6 µg/m^3 in 2023, a jump of 60.5 per cent.

Peak pollution months in major capitals, January to March 2019–2023



Mumbai's air pollution increased by 60 per cent from 2019 to 2023

City	Jan-Mar 2019	Jan-Mar 2020	Jan-Mar 2021	Jan-Mar 2022	Jan-Mar 2023
Delhi	137.4	112.8	149.3	121.2	124.2
Mumbai	50.2	58.3	77.6	73.4	80.6
Bengaluru	50.2	35.7	40.0	42.0	49.1
Kolkata	133.9	76.7	101.7	77.5	69.4
Lucknow	127.6	101.0	129.1	72.9	68.8
Patna	159.1	87.6	114.0	112.4	135.2

In contrast, the $PM_{2.5}$ concentrations dropped significantly in this quarter of 2023 in Lucknow and Kolkata, a steady improvement over the last two years. In Bengaluru, they dropped in 2020 compared to 2019, but rose steadily from 2021 to 2023.

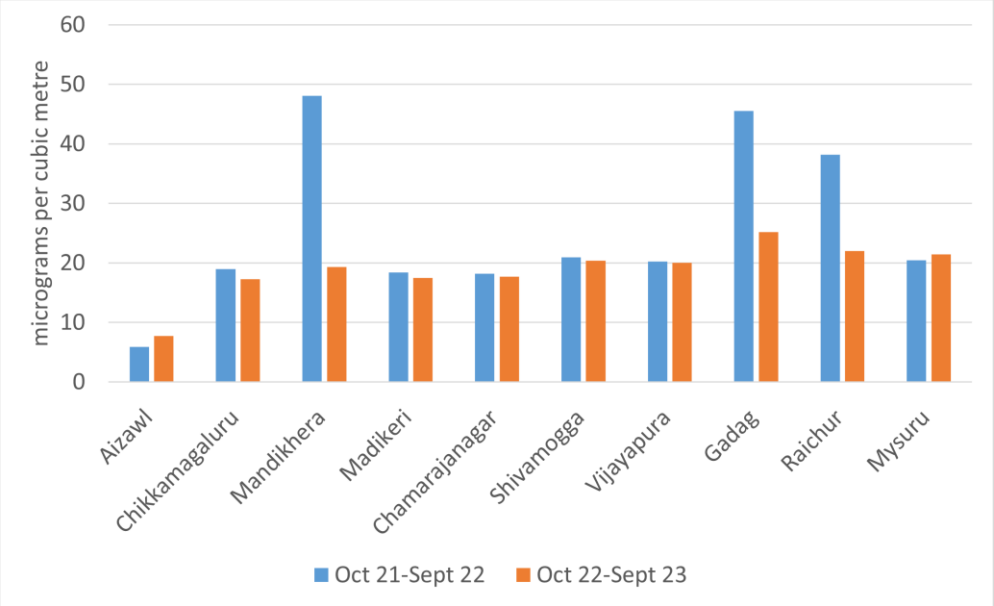
Delhi's and Patna's $PM_{2.5}$ levels in the first quarter of 2023 have shown a patchy performance – down compared to 2019 but up compared to 2022, indicating that more measures are needed to reduce pollution consistently.

The annual and quarterly $PM_{2.5}$ levels analysed for *all* these major capitals since 2019 were higher than the CPCB's 'good' level of 30 µg/m^3 and WHO's safe guideline of 5 µg/m^3.

Karnataka dominates: Top 10 places with India's cleanest air, October 2022-September 2023

Topping this list is Aizawl in Mizoram, which had a $PM_{2.5}$ concentration of 11 µg/m^3, followed by Chikkamagaluru in Karnataka (17.6 µg/m^3) and Mandikhera in Haryana (17.7 µg/m^3). The list consists of all places covered by the government's network of air quality monitors (CAAQMS), and not just the NCAP cities.

Places with India's Cleanest Air, October–September 2022-23



Haryana's Mandikhera and five places in Karnataka had cleaner air than a year earlier, but AQ worsened in Mizoram's Aizwal and three other places in Karnataka

Rank*	City	State	Oct 2021-Sept 2022	Oct 2022-Sept 2023	% Change
1	Aizawl	Mizoram	8	11.1	38.5%
2	Chikkamagaluru	Karnataka	18.1	17.3	-4.1%
3	Mandikhera	Haryana	36.9	17.6	-52.3%
4	Chamarajanagar	Karnataka	17.4	17.7	1.7%
5	Madikeri	Karnataka	20.7	18.1	-12.4%
6	Vijayapura	Karnataka	17.8	19.8	11%
7	Raichur	Karnataka	35.4	19.8	-44.2%
8	Shivamogga	Karnataka	21.9	19.8	-9.6%
9	Gadag	Karnataka	34.4	19.9	-42.3%
10	Mysuru	Karnataka	19.8	21.2	6.7%

**Annual ranking of cities based on $PM_{2.5}$ levels. Monitors recorded data for >70 per cent of the time for Oct 2022–Sept 2023.*

Six places showed an improvement in air quality in 2023 compared to the year before, while the remaining four showed a deterioration, including Aizwal, where levels rose from 8 to 11.1 µg/m^3. All were within the CPCB's 'good' limit of 30 µg/m^{3,} but above the WHO safe guideline of 5 µg/m^3. Notably, Karnataka dominates this top 10 list of places with India's cleanest air. However, a wider network of air quality monitors may well throw up many more such places.

Quotes:

***Aarti Khosla**, Director, Climate Trends*

"The analysis reflects that there has been improvement in the Indo-Gangetic Plain cities over the last few years. However, considering the enormous pollution load, these cities continue to experience the highest PM levels in the country. With NCAP nearing its first deadline, these studies highlight the data-level impact of policy action; however, deeper research is required to be able to attribute this improvement to sources of emissions and meteorological factors. For example, why in December 2022 did missing winter rains aggravate the pollution levels across the Indo-Gangetic Plains? Or what impacted the high PM levels in Mumbai in January–March this year? While measures like the Pradhan Mantri Ujjwala Yojana or hyperlocal developments like the peripheral highways around Delhi are positive actions, there is a need for a scientific approach to address air quality management in a sustained manner through an airshed approach."

***Ronak Sutaria**, Founder and CEO, Respirer Living Sciences*

"The current report, released at the time when GRAP begins in the National Capital Region (NCR), primarily tracks the trends in the NCAP cities during the past year and particularly during the peak pollution months. Key insights from the report show that Delhi's air quality has improved annually (by 4 per cent) and during the peak pollution (October–December by 10 per cent) compared to the previous year. However, it still remains at the top of the most polluted cities list. The analysis for cities like Patna indicates that while the city's air quality has deteriorated by 24 per cent over the last year, a closer look at the city's monitors shows that just 1 of 6 monitors recorded worsening AQ by 86 per cent. This initiative provides an accurate and periodic assessment of all the NCAP cities for the season-on-season and year-on-year assessment of their air quality via both reports and dashboards."

About the data

The $PM_{2.5}$ data used in this report was accessed on 30 September 2023, 4 PM, from the website of the Central Pollution Control Board (CPCB). The report's calculations are based on data gathered by the government's air quality monitoring stations using daily and annual averages. The rankings are based on the data collected from the CPCB website

for the 131 non-attainment cities identified by the National Clean Air Programme (NCAP). The monitors in these cities with a yearly uptime of more than 70 per cent for the October 2022–September 2023 were considered for analysis. The annual and quarterly averages have been calculated by averaging the measurements of the respective stations. For cities with multiple monitors, an average of the $PM_{2.5}$ levels of all the monitors was calculated. The cities were then ranked by their $PM_{2.5}$ averages in decreasing order. Instances where the monitors did not record any information were considered missing data. To view the tables in this report in greater detail, click here.

About Respirer Living Sciences and Respirer Reports

http://www.respirer.in/

Respirer Living Sciences, Pune, is a pioneer in Make-in-India emissions monitoring and reporting technologies. Between 2017 and 2023, the number of its deployed air quality monitors went from ~150 to over 2,500. It has partnered with prominent institutions like the IITs, governments, think tanks, corporates and CSOs in India and abroad. Respirer's emission monitors are low-cost, its solutions high-tech, AI-driven. These measure both greenhouse gases as well as the most prominent air pollutants – $PM_{2.5}$ (fine particulate matter), nitrogen dioxide, ozone, carbon monoxide, volatile organic compounds, carbon dioxide and methane.

Respirer Reports, a part of Respirer Living Sciences, produces data-driven reports and analysis. It analyses emissions data and works with clients investing in Respirer's clean air technologies for both outdoor and indoor air quality. For more, visit http://www.respirer.in/reports.

For more information, write to research@respirer.in.

About Climate Trends

Climate Trends is a research-based consulting and capacity building initiative that aims to bring greater focus on issues of environment, climate change and sustainable development. We specialise in developing comprehensive analyses of complex issues to enable effective decision-making in the private and public sector.