Winterpollution in the eastern states of India: Overview of the winter air quality crisis

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As the winter comes to an end, the Urban Lab at Centre for Science and Environment (CSE) analyses the air quality trends in the states of eastern India -- Bihar, West Bengal, Odisha and Jharkhand.

With the winter season coming to an end, the Urban Lab at Centre for Science and Environment (CSE) has analysed air quality trends during the winter months (October to February) in cities of eastern states of West Bengal, Bihar, Odisha and Jharkhand. This is an assessment seasonal trends in PM2.5 concentration for the period 1 October to 28 February for 2019, 2020, 2021, 2022 and 2023. Winter inversion, cool and calm conditions trap local pollution that is already high. This is part of the third edition of Urban Lab's Air Quality Tracker Initiative since 2020-21.

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.

In West Bengal, real time monitors in Durgapur and Haldia became operational only near the end of 2020. Many new stations have been added in November 2022 in Odisha: one station each in Baripada, Bileipada, Keonjhar, Nayagarh, Rairangpur, Rorkela, Suakati and Tensa. This limits the possibility of doing long term trend analysis for these cities

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 USEPA method for this analysis.

The cities of eastern states are increasingly falling into the pincer grip of toxic particulate pollution during winter season. The problem is also spreading quickly to smaller cities and towns of the region.

While the bigger cities that are part of the national clean air programme like Patna and Kolkata (NCAP) have witnessed marginal improvement in winter average of PM2.5 levels compared to previous two winters, their levels are still high.

The smaller towns of Bihar, Begusarai, Bettiah and Siwan have the recorded worst winter air in the region with their seasonal average exceeding 200 µg/m³. Nitrogen dioxide (NO2) pollution is also high in the cities and towns of the region with Arrah recording staggering 113 µg/m³ monthly average for November.

This analysis is a stark reminder of the rapid spread of pollution. More cities and smaller towns are scaling the pollution height and dotting the pollution map. This once again vindicates the need for a strong state-wide and regional management of air pollution. This is needed to control local pollution sources including vehicles, industry, open burning and construction dust, as well as the impact of upwind pollution sources on downwind cities and towns..

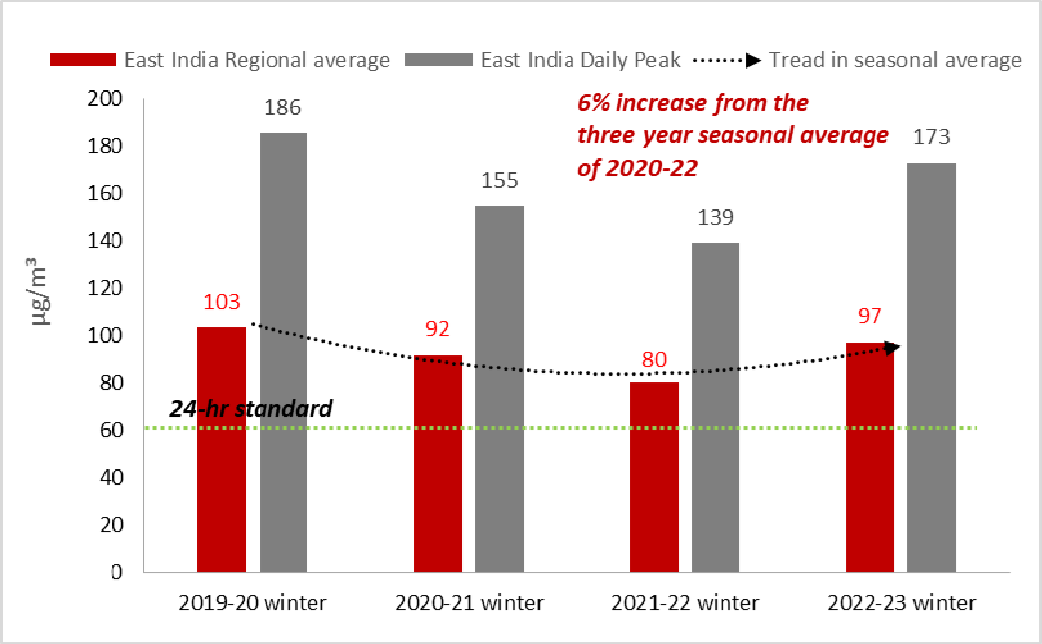
Additionally data gap is also a challenge in the region. Even though the real time monitors have increased in the region including Jharkhand some of these could not be used due to data gaps and quality. Some of these are new and therefore long term data is not available. Therefore, the data is indicative of the current status and seasonal variation in particulate pollution in medium and smaller cities.

Key findings

The eastern states experienced the most polluted winter season since 2019-20: 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 1: Trend in winter PM2.5 levels in the cities of eastern states (1 Oct 2022-28 Feb 2023)*. 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 was recorded on 1 January and daily regional average stood at 173 µg/m³. Peak was 24 per cent higher compared to the peak of 2021-22 winter and 8 per cent higher compared to the mean peak of previous three winters.

Graph 1: Trend in winter PM2.5 levels in the cities of eastern states (1 Oct 2022-28 Feb 2023)



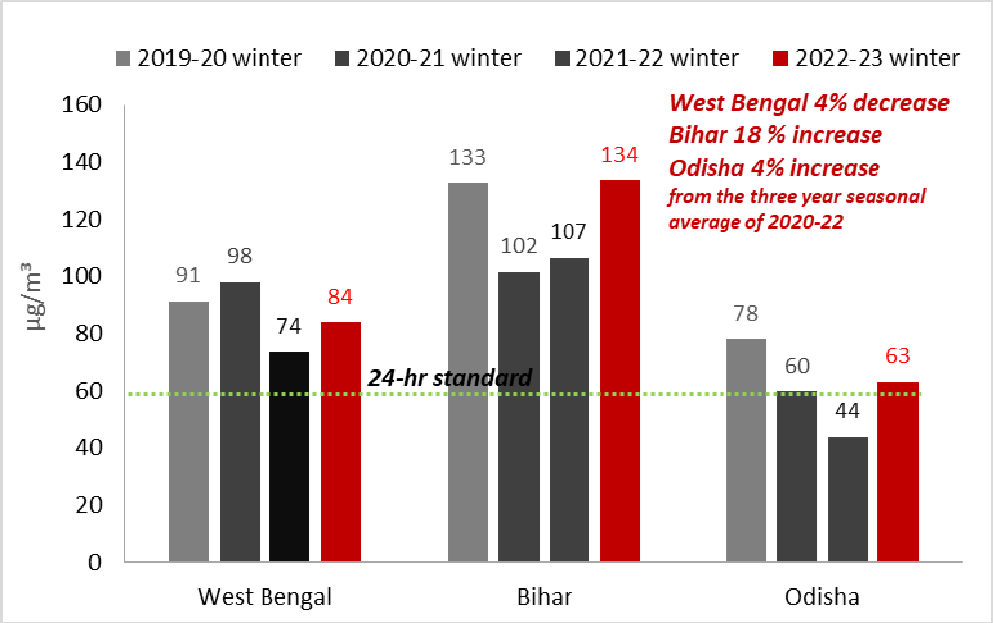
Note: 9 cities that constitute East India regional average are Kolkata, Howrah, Asansol, Siliguri, Patna, Gaya, Muzaffarpur, Talcher and Brajrajnagar. 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data.

Most cities have experienced worsening of winter PM2.5 levels: West Bengal's winter average PM2.5 this year is 14 per cent higher than the previous winter. Bihar registered 26 per cent and Odisha 44 per cent higher winter average compared to the previous winter (See *Graph 2: Trend in PM2.5 levels in October – February in eastern states*).

On a long term basis, Bihar registered 18 per cent increase and Odisha 4 per cent increase from the mean level of previous three winters. However, the seasonal air quality in West Bengal this winter is 4 per cent better than the mean of previous three winters. The monitoring station in Jharkhand has no PM2.5 data for last 2 years, there 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 in the East followed by West Bengal with average PM2.5 of 84 µg/m³ and Odisha registered seasonal average of 63 µg/m³ (See *Graph 2: Trend in PM2.5 levels in October-February for sub-regions of East India*).

Graph 2: Trend in PM2.5 levels in Oct- Feb in eastern states

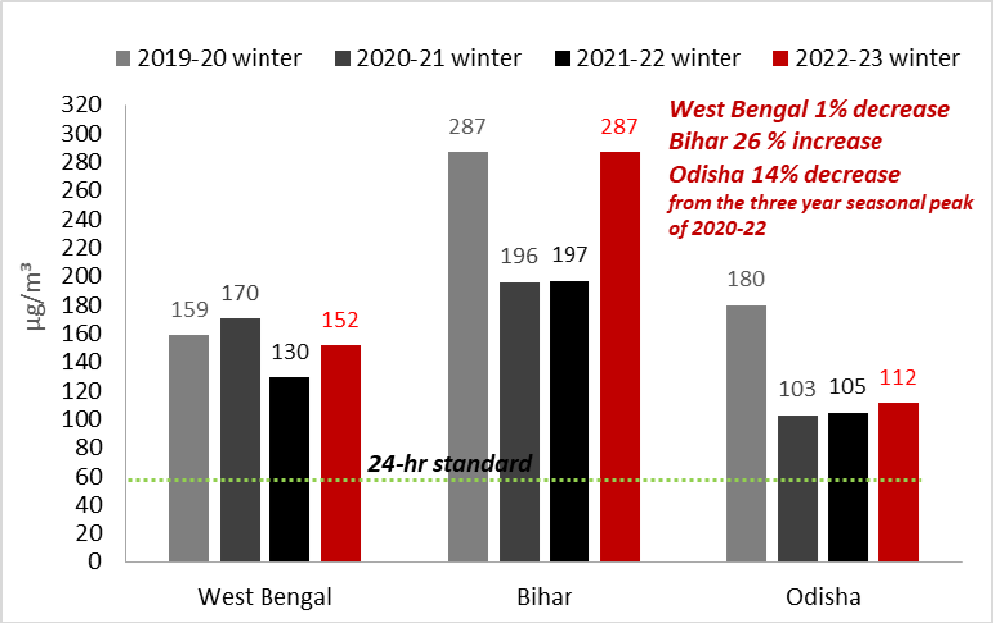


Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

Peak pollution is dangerously high in all eastern states: In absolute concentration terms, Bihar daily peak PM2.5 of 287 µg/m³ was the highest among states of East India. West Bengal's peak PM2.5 was 152 µg/m³ and Odisha's peak was 112 µg/m³ this winter (See *Graph 3: Trend in PM2.5 peaks during October-February for eastern states*).

On 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 3: Trend in PM2.5 peaks during Oct- Feb for eastern states



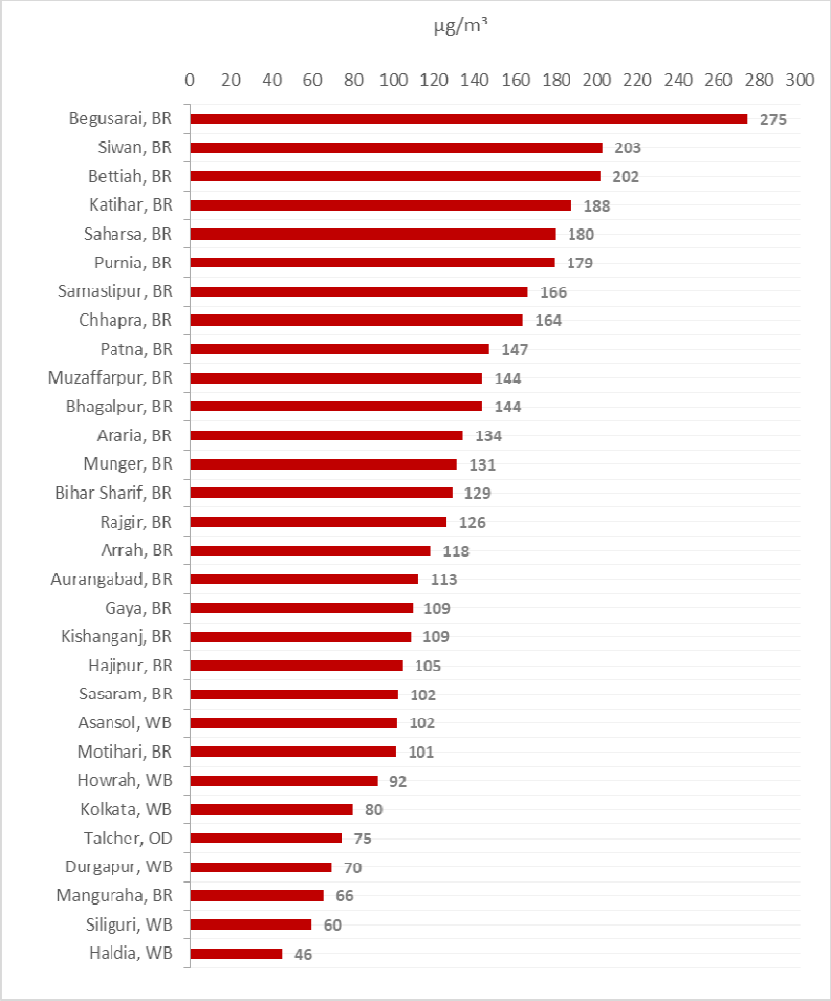
Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

Smaller cities of Bihar are most polluted in the region: Begusarai was the most polluted city in the East 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 the East are located in Bihar (See *Graph 4: 1 October 2022- 28 February 2023 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 it is not possible to capture the larger landscape.

Haldia in West Bengal was the least polluted city with PM2.5 average of 46 μg/m³ followed by Siliguri, and Manguraha in Bihar with winter average of 60 μg/m³ and 66 μg/m³ respectively.

Graph 4: 1 October 2022-28 February 2023 PM2.5 level among East Indian cities



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

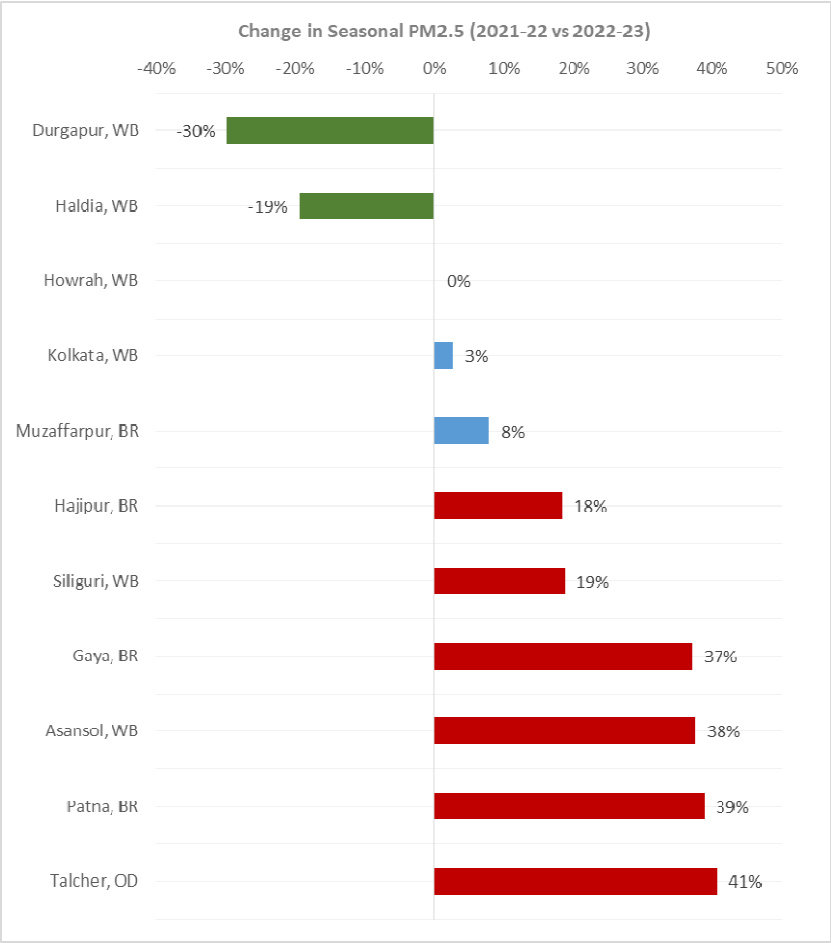
Patna registered the highest increase in winter pollution this winter among the major cities in the region: Patna in Bihar and Talcher in Odisha were the worst performers and registered an increase of 39 per cent and 41 per cent from the previous year respectively. These were followed by Asansol in West Bengal and Gaya in Bihar recorded an increase of 38 per cent and 37 per cent respectively. (See *Graph 5: 1 October-28 February PM2.5 level among East Indian cities 2021-22 vs 2022-23*).

However, Howrah (0 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 corresponding period previous year. Durgapur registered most improvement with 30 per cent and Haldia registered with 19 per cent lower PM2.5

compared to previous year (See *Graph 5: 1 Change in average PM2.5 level during winter in eastern cities 2021-22 vs 2022-23*).

Graph 5: Change in average PM2.5 level during winter in eastern 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 mean of all city stations. Cities with data in both 2021 and 2022 are compared.
Source: CSE analysis of CPCB real-time data

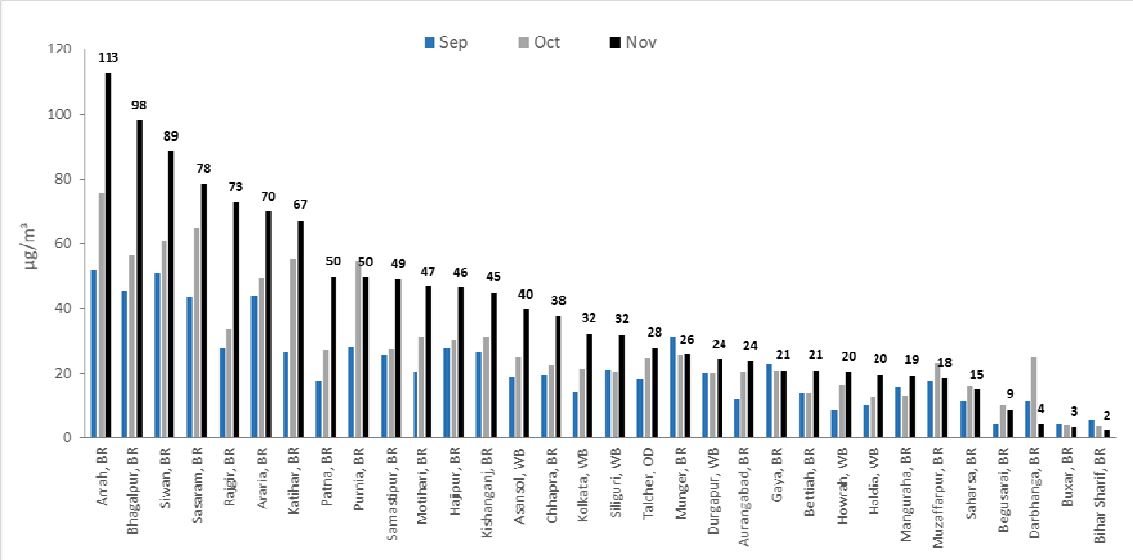
Increasing levels of Nitrogen dioxide (NO2) during November: There is significant increase in NO2 concentration during November compared to October and September. NO2 comes entirely fromcombustion sources and significantly from vehicles. Patna has registered the greatest increase of 2.9 times with the maximum build-up of NO2 between September and November. Katihar and Rajgir each registered 2.6 times increase in NO2. Motihari, Kolkata and Howrah have registered 2.3 times increase in NO2 compared to SeptembertoNovember.

In absolute concentration terms, Arrah in Bihar registered the highest NO2average of 113 µg/m³ (See *Graph 6: Graph6:TrendinNO2 levelsin the citiesof eastern states*). It is

followed by Bhagalpur with 98 µg/m³ and Siwan with 89 µg/m³.

AmongWest Bengal cities Asansol with monthly average of 40 µg/m³ was the most polluted in the region.

Graph6:TrendinNO2 levelsin the citiesof eastern states

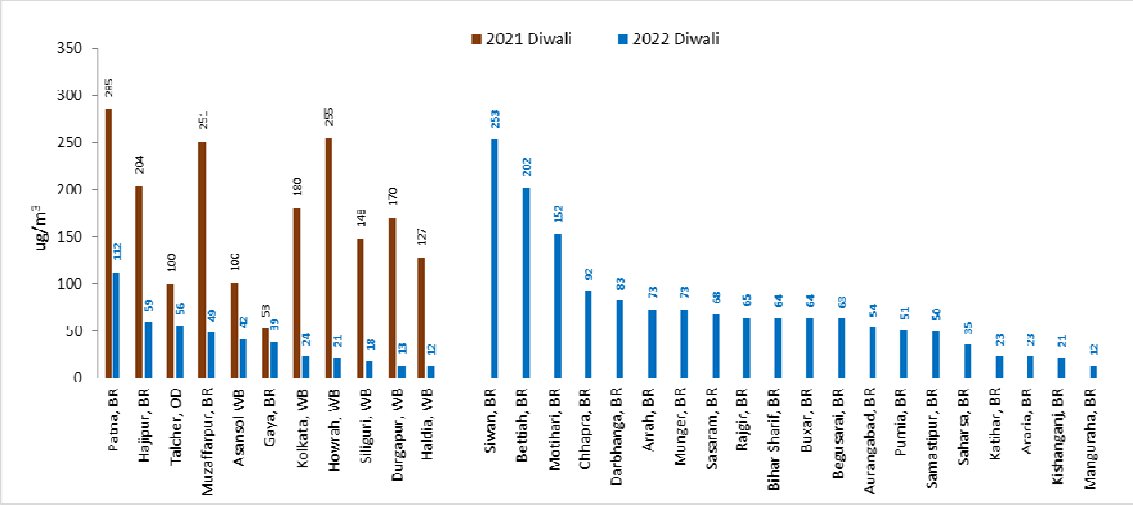


Note: NO2 values for sub-regions are based on the average of citywide values of all the cities in that region. NO2 values for citieswith more than one monitoring stations is based on average of all stations that have continuous and adequate data.Data uptill30November 2022.
Source:CSEanalysisofreal-timedatafromCPCBportal

Diwali pollution is highest among small towns of Bihar among the eastern states: ThisDiwali is least polluted compared to previous year's Diwali forallmajorcitiesintheregion. However, smaller cities of Bihar had witnessed the maximum increase on Diwali night(See*Graph7:TrendinDiwalinightpollution amongmajorcities ofeastern states*).

PollutionlevelonDiwalinight(8pmto8am)in cities shot up by 0.2 – 2.3 times the average level recorded during seven nights preceding Diwali (See *Graph 8:Diwali night pollution among cities of eastern states*). This Diwali nine out of 32 stations have recorded an increase in pollution on the day of Diwali. Motihari in Bihar saw the greatest jump of 2.3-times higher PM2.5 level on Diwalinight at 152 µg/m³. It is followed by Siwan and Bettiah each with 1.8-times higher PM2.5 concentration. Bihar cities dominate the top 15 listof most polluted Diwali nights. AmongWest Bengal cities Asansol recorded Diwali night PM2.5 levels at 42 µg/m³. Haldia and Manguraha each with 12 µg/m³ hadtheleastpollutedDiwalinight in theregion followed by Durgapur with 13 µg/m³.

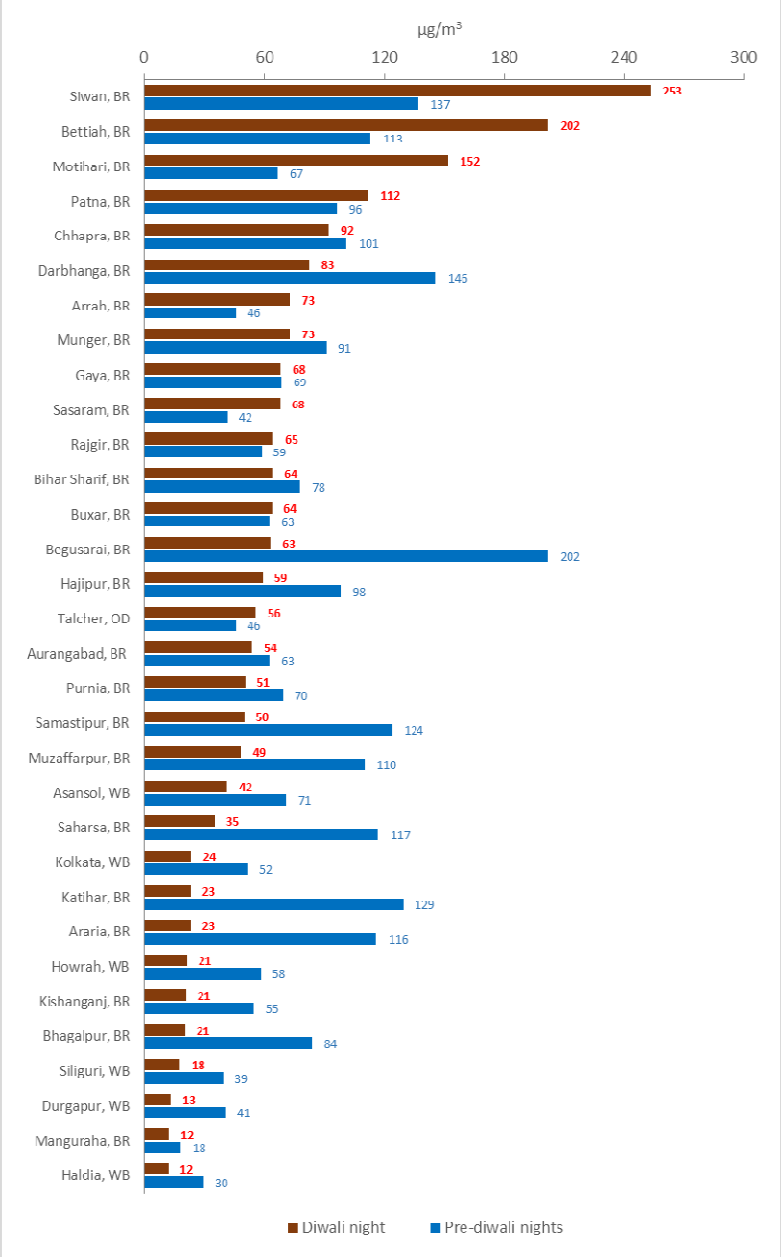
Graph7:TrendinDiwalinightpollutionamongmajorcitiesof eastern states



Note: PM2.5 values for cities with more than one monitoring stations is based on average of all stations that have continuous andadequate data for complete assessment period. Diwali night is considered from 8.00PM to 8.00AM on 4November 2021 and 24 October 2022.

Source:CSEanalysisofreal-timedatafromCPCBportal

Graph8:TrendinDiwalinightpollutionamongmajorcitiesof eastern states



Note: PM2.5 values for cities with more than one monitoring stations is based on average of all stations that have continuous andadequate data for complete assessment period. Diwali night is considered from 8.00PM October 24 to 8.00AM October 25. Pre-Diwali nightis averageofseven nights(8.00PM-8.00AM)precedingDiwali. Source:CSEanalysisofreal-timedatafromCPCBportal

Step up action

High winter pollution is an indicator of deeper spread of air pollution in the eastern region. The moment winter weather turns hostile due to inversion, cold and calm conditions, pollution gets trapped and spirals. This requires aggressive strategy to control pollution not only in the bigger cities but also across the region to control pollution from vehicles, industries, open burning of waste, construction, household use

of solid fuels, and other area sources. It is necessary to reduce pollution in a targeted manner to meet the clean air standards.

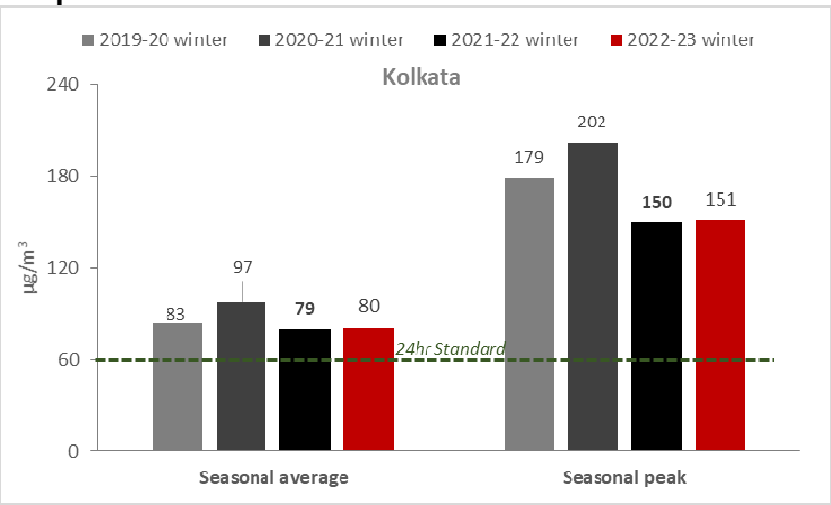
PARTII: WinterpollutioninindividualcitiesofEast India

West Bengal:Kolkata

Winter pollutionlevel in Kolkata this season has been 7 per cent lower than the mean of previous three winters but is still considerably higher than the standard (See*Graph9:PM2.5wintertrend inKolkata*). Similarly, there has been 15 per cent decline in winter peak compared to the mean of peaks of previous of three winters.

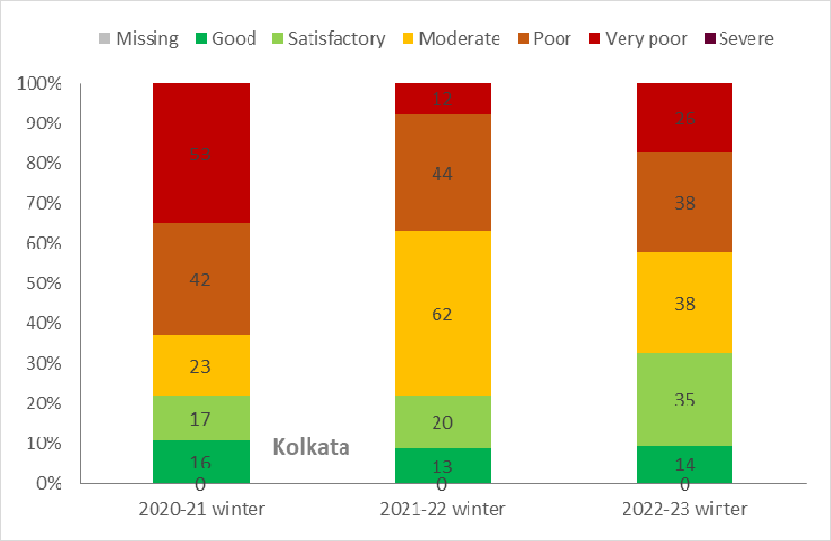
AQIcategorizationofday'sshowsthatthecity'sairquality has not deteriorated to severe days in last three years but the number of days with poor and very poor airqualityhas increased this winter compared to last year. However, it has not been as bad as winter of 2020-21 (See*Graph10: PM2.5AQItrend inKolkata*).

Graph9: PM2.5wintertrendinKolkata



Note: PM2.5 values is based on station that have continuous and adequate data. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Graph10:PM2.5AQItrendinKolkata



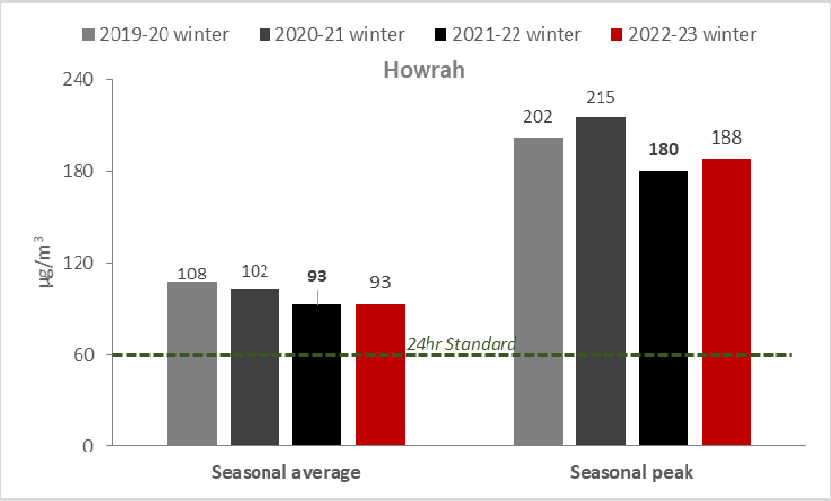
Note:PM2.5valueis basedonstationthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly.Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

West Bengal: Howrah

Winter pollutionlevel 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 6 per cent decline in winter peak compared to the mean of peaks of previous of three winters (See*Graph11:PM2.5wintertrendinHowrah*)

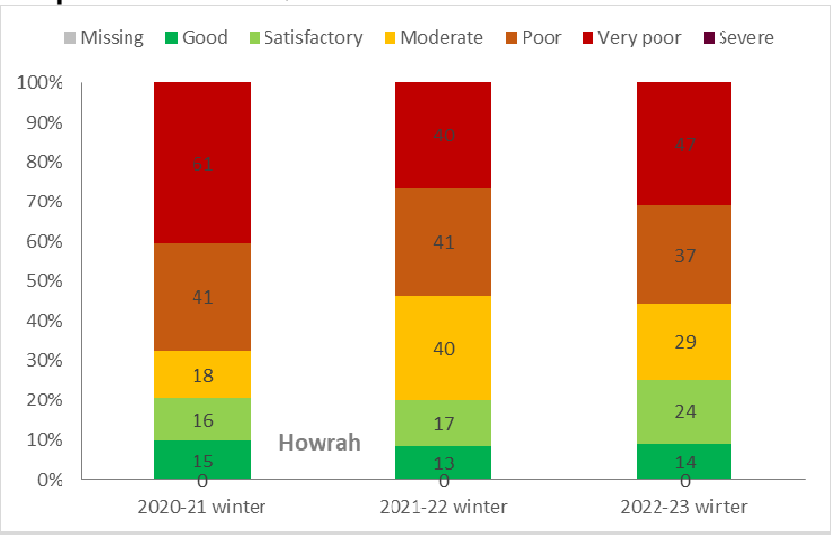
AQIcategorizationofday'sshowsthatthecity'sairquality has not deteriorated to severe days in last three years but the number of days with poor and very poor airqualityhas increased this winter compared to last year. However, it has not been as bad as winter of 2020-21 (See*Graph12: PM2.5 AQItrendinHowrah*).

Graph11:PM2.5wintertrendinHowrah



Note: PM2.5 values is based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Graph12: PM2.5AQItrendinHowrah



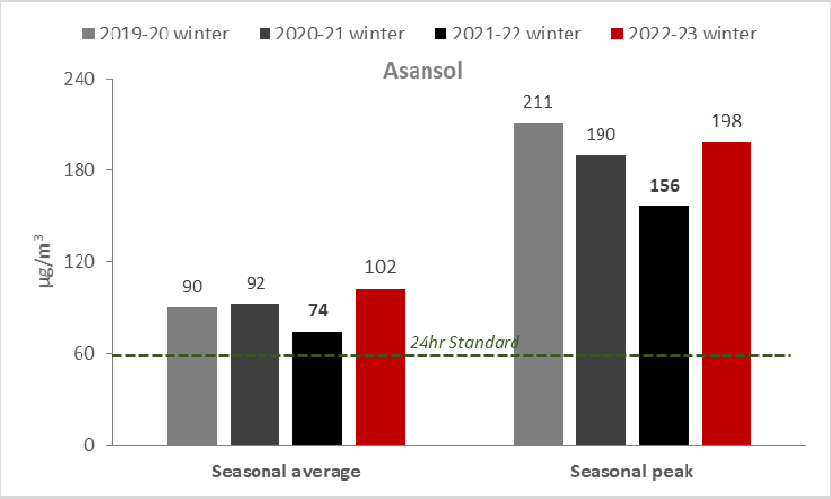
Note:PM2.5valueisbasedonstationsthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly. Winter is defined as 1 October - 28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

West Bengal: Asansol

Winter pollutionlevel in Asansol this season has been 20 per cent higher than the mean of previous three winters and with seasonal average of 102 µg/m³ the city's air quality is considerably higher than the standard. Similarly, there has been 6 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph13:PM2.5wintertrendinAsansol*).

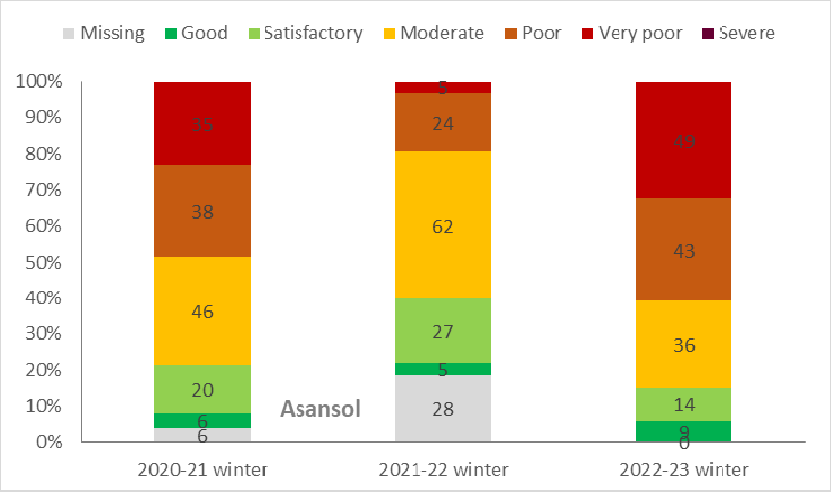
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated considerably this winter with 92 days with poor and very poor airquality, a considerable increase compared to previous two winters(See*Graph14: PM2.5 AQItrendinAsansol*).

Graph13:PM2.5wintertrendinAsansol



Note: PM2.5 values is based on stations that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Graph14: PM2.5AQItrendinAsansol



Note:PM2.5valueisbasedonstationsthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly. Winter is defined as 1 October - 28 February.

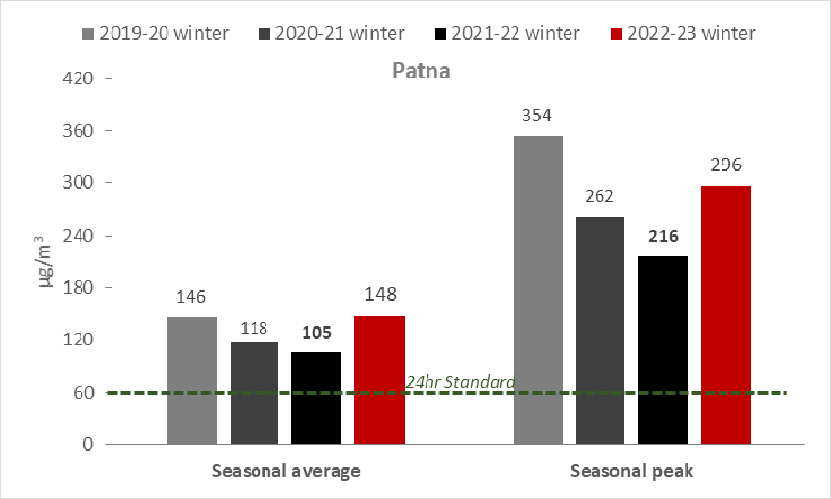
Source:CSEanalysisofreal-timedatafromCPCBportal

Bihar: Patna

Winter pollutionlevel in Patna this season has been 20 per cent higher than the mean of previous three winters and with seasonal average of 148 µg/m³ the city's air quality is considerably higher than the standard. Similarly, there has been 7 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph15: PM2.5wintertrendin Patna*).

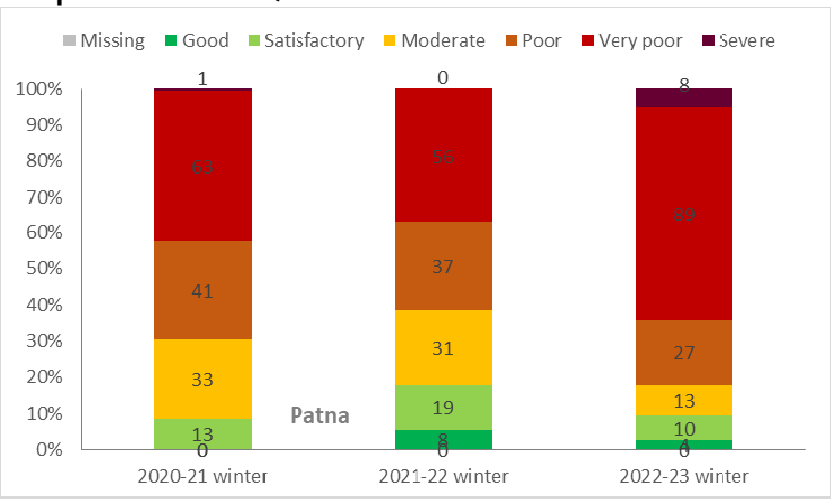
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated considerably this winter with 8 days of severe airquality and 89 days of very poor air quality, a considerable increase compared to previous two winters(See *Graph 16: PM2.5 AQI trend in Patna*). There had been only one day of severe air quality in the city in previous two winters.

Graph15:PM2.5wintertrendinPatna



Note: PM2.5 values is based on station that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Graph16:PM2.5AQItrendinPatna



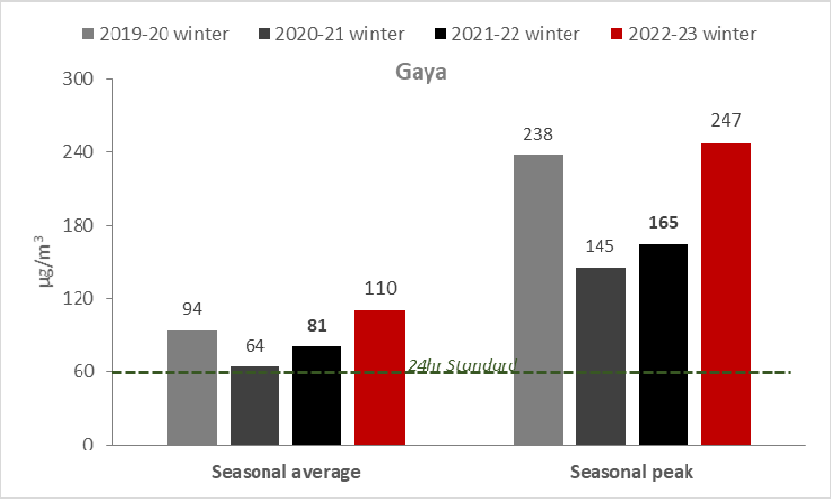
Note: PM2.5 value is based on station that have continuous and adequate data for complete assessment period. AQI is based onPM2.5sub-categoryonly.Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Bihar: Gaya

Winter pollutionlevel in Gaya this season has been 39 per cent higher than the mean of previous three winters and with seasonal average of 110 µg/m³ the city's air quality is considerably higher than the standard. Similarly, there has been 35 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph17: PM2.5wintertrendin Gaya*).

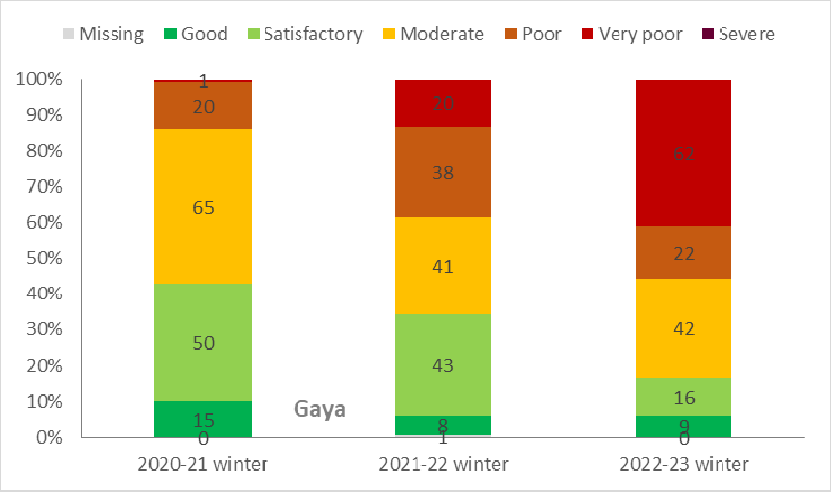
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated considerably this winter with 62 days of very poor air quality, a considerable increase compared to previous two winters(See *Graph 18: PM2.5 AQI trend in Gaya*). There were 20 "very poor" days in 2021-22 winter and just one "very poor" days in 2020-21 winter.

Graph17:PM2.5annualandwintertrendinGaya



Note: PM2.5 values is based on station that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Graph18:PM2.5AQItrendinGaya



Note: PM2.5 value is based on station that have continuous and adequate data for complete assessment period. AQI is based onPM2.5sub-categoryonly.Winter is defined as 1 October -28 February.

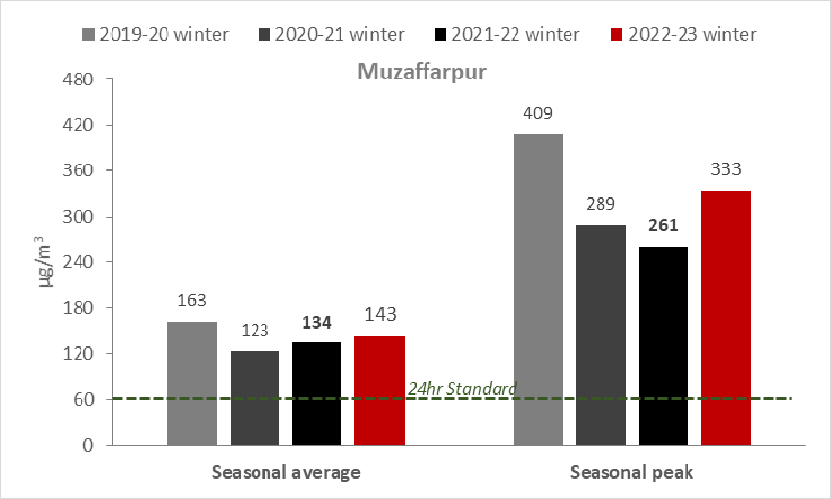
Source:CSEanalysisofreal-timedatafromCPCBportal

Bihar: Muzaffarpur

Winter pollutionlevel in Gaya this season has been 2 per cent higher than the mean of previous three winters and with seasonal average of 143 µg/m³ the city's air quality is considerably higher than the standard. Similarly, there has been 4 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph19:PM2.5wintertrend in Muzaffarpur*).

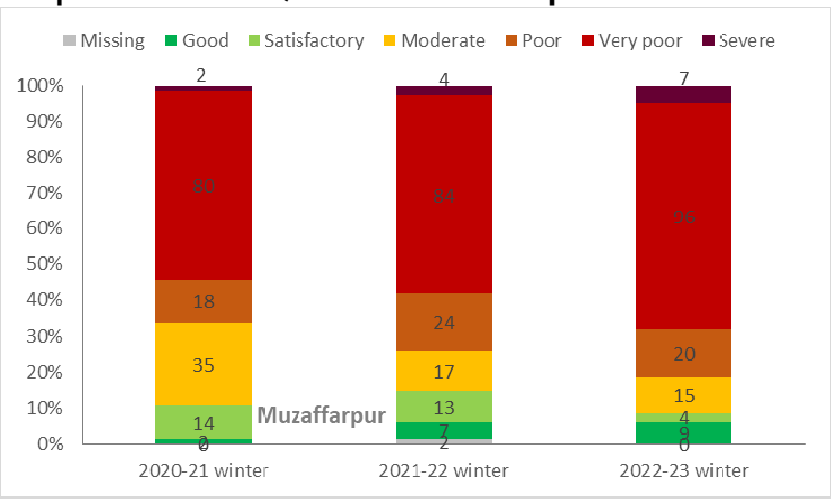
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated considerably this winter with 7 days of severe airquality and 96 days of very poor air quality, a considerable increase compared to previous two winters(See *Graph 20: PM2.5 AQI trend inMuzaffarpur*). There were 4 "severe" days in 2021-22 winter and just 2 "severe" days in 2020-21 winter.

Graph19: PM2.5wintertrendin Muzaffarpur



Note: PM2.5 values is based on station that have continuous and adequate data for complete assessment period. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Graph20: PM2.5AQItrendin Muzaffarpur



Note:PM2.5valueis basedonstationthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Annex 1

Table: PM2.5 level at station levels 1 Oct 2022-28 Feb 2023

Station	State	1 Oct 2021 - 28 Feb 2022	1 Oct 2022 - 28 Feb 2023
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
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 $\mu g/m^3$.

Source: CSE analysis of CPCB real-time data