Cities of the western states of Maharashtra and Gujarat in grip of growing winter pollution
AnumitaRoychowdhury, AvikalSomvanshiand Sharanjeet Kaur

Centre for Science and Environment, New Delhi, April, 2023

Growing problem of particulate pollution in the cities of the western states of Maharashtra and Gujarat hogged attention during this winter. This winter has been the most polluted in last four years in this region.
This has emerged from the new analysis of the winter PM2.5 trends in the cities of western states of Maharashtra and Gujarat (October 1, 2022 to February 28, 2023), that has been carried out by the Urban Lab at the Centre for Science and Environment (CSE).

The fact that the big cities as well as smaller towns have experienced the rise in winter PM2.5 levels, indicates rapid spread of the air pollution problem in the region. This is evident in both seasonal average and peaks. While local pollution is increasing in these rapidly motorising and developing cities, the regional influence is further aggravating the challenge. This is overpowering the advantage of natural ventilation of the coastal climate. This demands immediate roadmap to control pollution form the key sources across the region.

While in absolute terms Gujarat has higher pollution level, it is rising faster in Maharashtra. Most polluted locations in the region are located in Mumbai and Navi Mumbai. Vapi and Surat are among the most polluted locations in Gujarat. Nagpur registered the highest increase in pollution with 105 per cent rise compared to the previous winter.

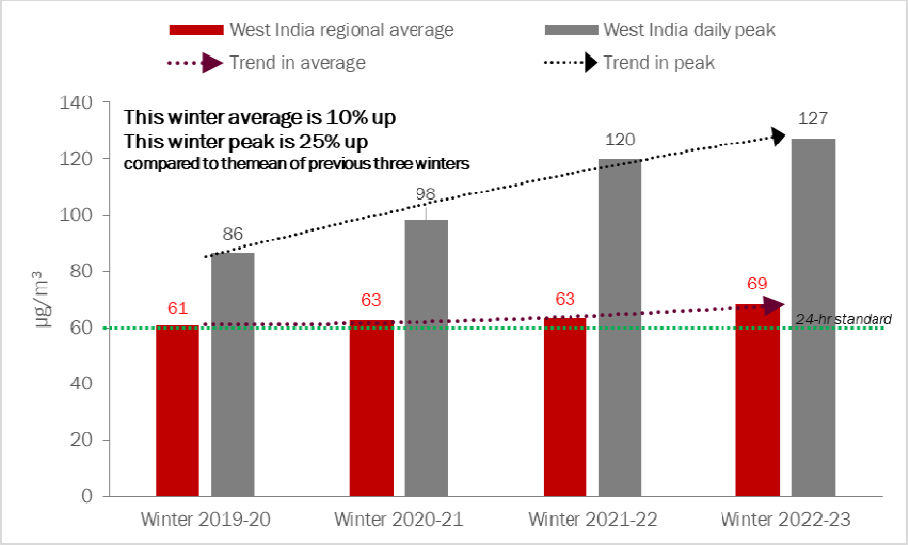
In these states, winter pollution typically sets in during late November and early December when the cooler and calmer conditions trap local pollution. This analysis is part of the third edition of Urban Lab's Air Quality Tracker Initiative which was started in 2020-21 winter. This analysis is based on the real time data available from the current working air quality monitoring stations in these two states. A huge volume of data points have been cleaned and data gaps have been addressed based on 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. Even though there are multiple real time monitors in a few cities of these states but many could not be considered for long term analysis due to data gaps and lack of quality data. In several cases the real time monitors have been set up recently and therefore long term data is not available.

Key findings

The winter average of PM2.5 in the western cities was highest in last four years: The average PM2.5 concentration across cities in the west stood at 69 µg/m³ this winter (See *Graph 1: Regional trend in average PM2.5 average in cities of Gujarat and Maharashtra*). It is 10 per cent higher than the mean of previous three winter seasons (October to February). Daily peak for the region this winter happened on 24 October 2022 (day after Diwali) when the level was127 µg/m³. It was 25 per cent higher than the mean of previous three winter peaks. 15 cities that have been considered from the western states for assessment of the regional trend include 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.

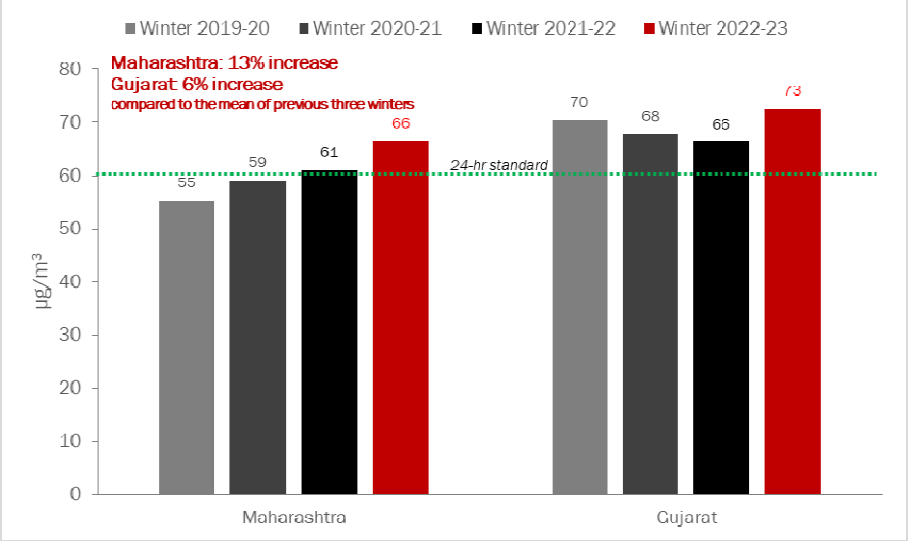
Graph 1: Regional trend in average PM2.5 average in cities of Maharashtra and Gujarat



Source: CSE analysis of CPCB real-time data.

Most polluted winter in last four years: The average winter pollution level in the cities of Maharashtra rose by 13 per cent compared to the mean of previous three winter seasons. Winter pollution has been rising in Maharashtra on yearly basis and stood at of 66 µg/m³ this winter. In absolute terms, Gujarat was more polluted of the two states with winter average of 73 µg/m3. Gujarat registered increase of 6 per cent compared to the mean of previous three winter (See*Graph 2: Seasonal winter trend in PM2.5 levels in cities Maharashtra and Gujarat*). Winter pollution was on a decline in Gujarat since 2019 but it spiked up this winter.

Graph 2: Seasonal winter trend in PM2.5 levels in cities of Maharashtra and Gujarat

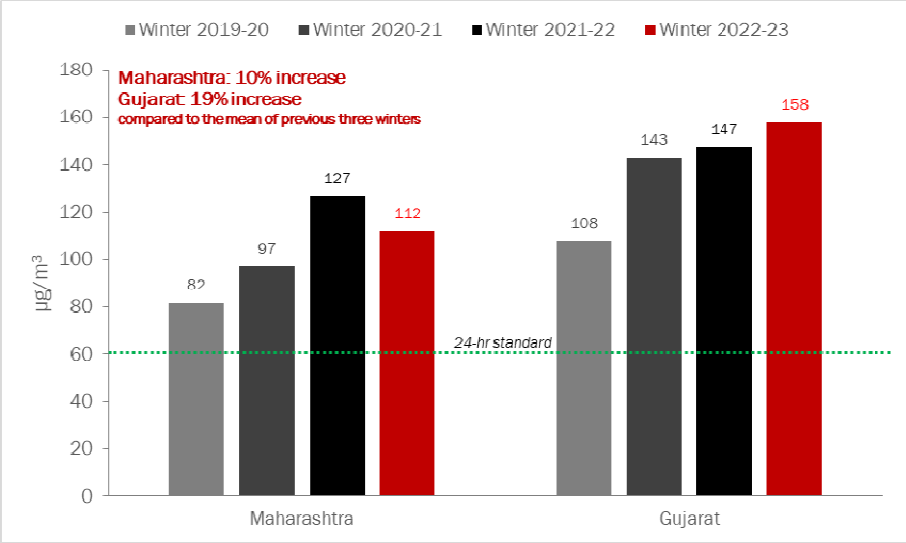


Note: 1 October-28 February average is based on mean of daily averages where continuous data is available since 2019.
Source: CSE analysis of CPCB real-time data

Peak pollution growing faster in Gujarat but is a problem in Maharashtra as well: Gujarat has its daily peak of PM2.5 at 158 µg/m3 on 24 October 2022. This was the highest regional peak in 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 in the season on 2 December 2022. Maharashtra's daily PM2.5 peak stood at 112 µg/m3, which is marginally lower than the 2021-22 winter peak but 10 per cent higher than the mean of the previous three winter peaks (See *Graph 3: Trend in winter PM2.5 peaks in the two states*).

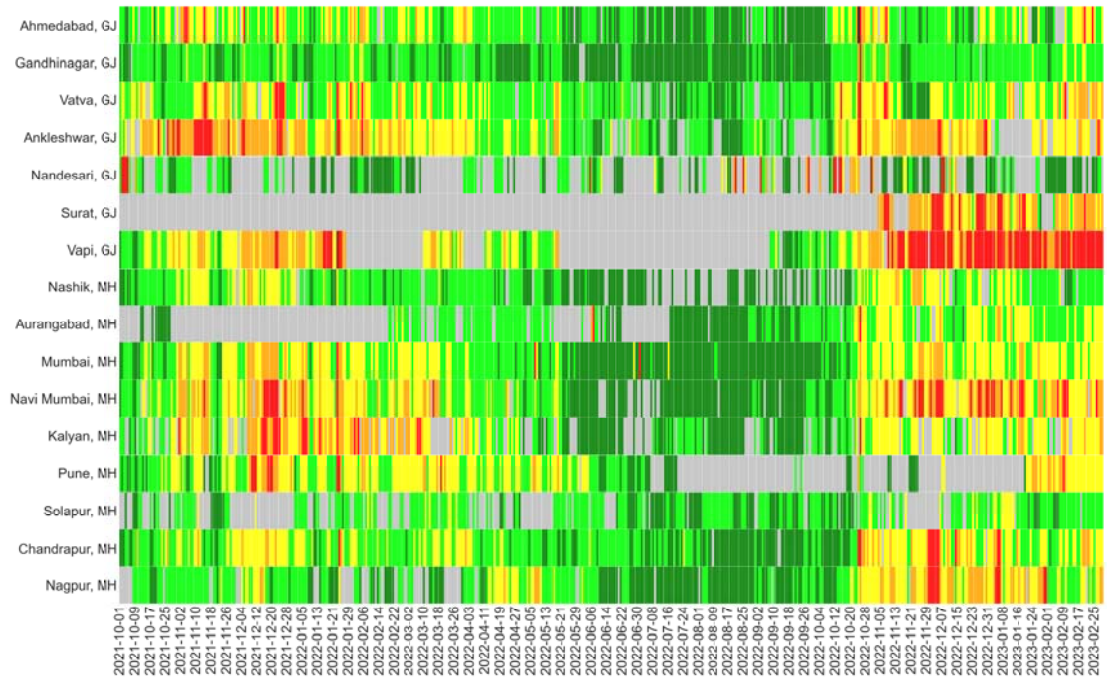
Graph 3: Trend in winter PM2.5 peaks in the two states



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

Regional influence of pollution is sharply evident in synchronized spread of winter pollution across the cities: Worsening of air quality starts mid-October across Western India in a synchronized fashion as weather starts to cool down and winds slow down (See *Graph 4: Air quality heat map of cities in Maharashtra and Gujarat*). But the analysis is hampered by poor data quality among the stations in the region. Data for 96 days is missing from stations in Pune, while in Nandisaridata of 68 days is missing. There are large gaps in data from other stations as well.

Graph 4: Air quality heat map of cities in Maharashtra and Gujarat



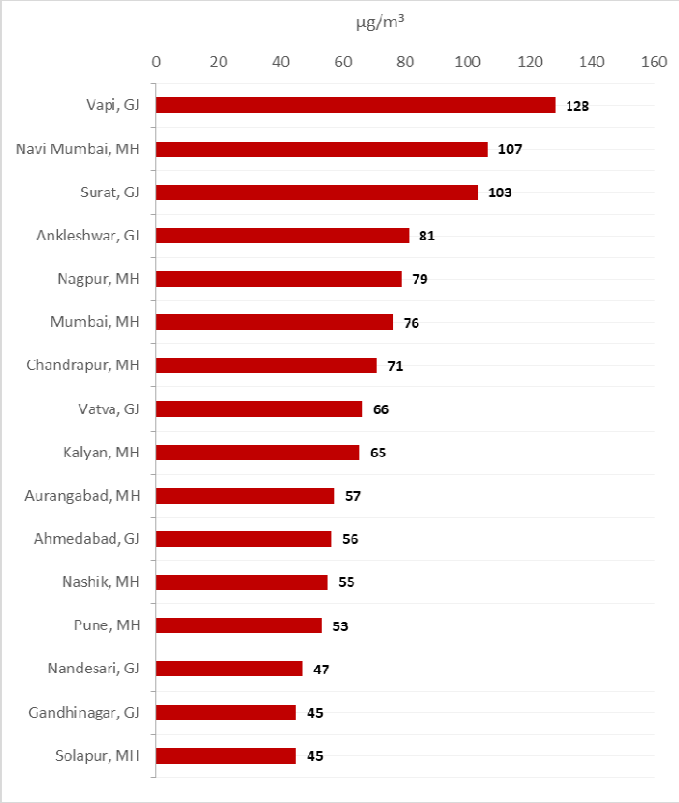
Note: Data up till 28 February 2023. Cell colour is based on the official colour-scheme of AQI sub-categories.
Source: CSE analysis of CPCB real-time data

The pollution hotspots and cleaner cities: Navi Mumbai and Vapi are among the most polluted among the cities of these states. The winter average PM2.5 level in Vapi was 128 µg/m³. In Navi Mumbai it was 107 µg/m³, and Surat with 103 µg/m³ (See *Graph 5: Winter average PM2.5 levels in cities of the two states).* On the other hand, Gandhinagar in Gujarat was the least polluted city with PM2.5 average of 45 µg/m³. Solapur in Maharashtra also has a seasonal average 45 µg/m³ but due to excessive missing data (36 days of missing data) this cannot be said with certainty. Same goes for cities of Nandesari and Pune which have high number of missing data.

Nagpur followed by Navi Mumbai registered the highest increase in winter pollution: Nagpur in Maharashtra was the worst performer and registered an increase of 105 per cent compared to the preceding winter. It was followed by Navi Mumbai and Vapi with an increase of 59 per cent and 52 per cent.

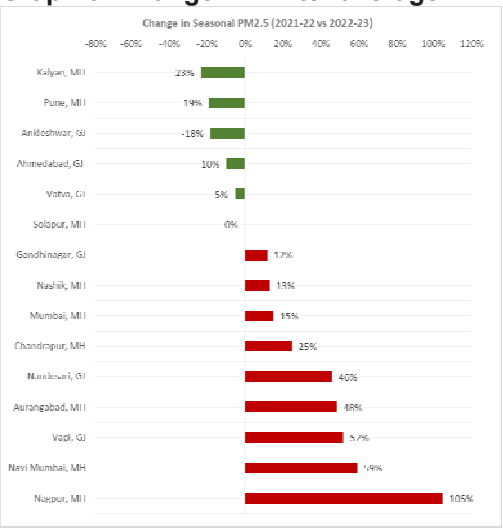
However, Kalyan in Maharashtra showed the most improvement in air quality this season (23 per cent) compared to the corresponding period during previous year. It is followed by Pune with 19 per cent, Ankleshwar with 18 per cent, Ahmedabad with 10 per cent and Vatva with 5 per cent improvement in PM2.5 levels compared to the previous year. (See *Graph 6: Change in winter average of PM2.5 level in cities of two states (2021-22 vs 2022-23).*

Graph 5: Winter average PM2.5 levels in cities of the two states
(1 October 2022-28 February 2023)



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

Graph 6: Change in winter average PM2.5 level in cities of the two states (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

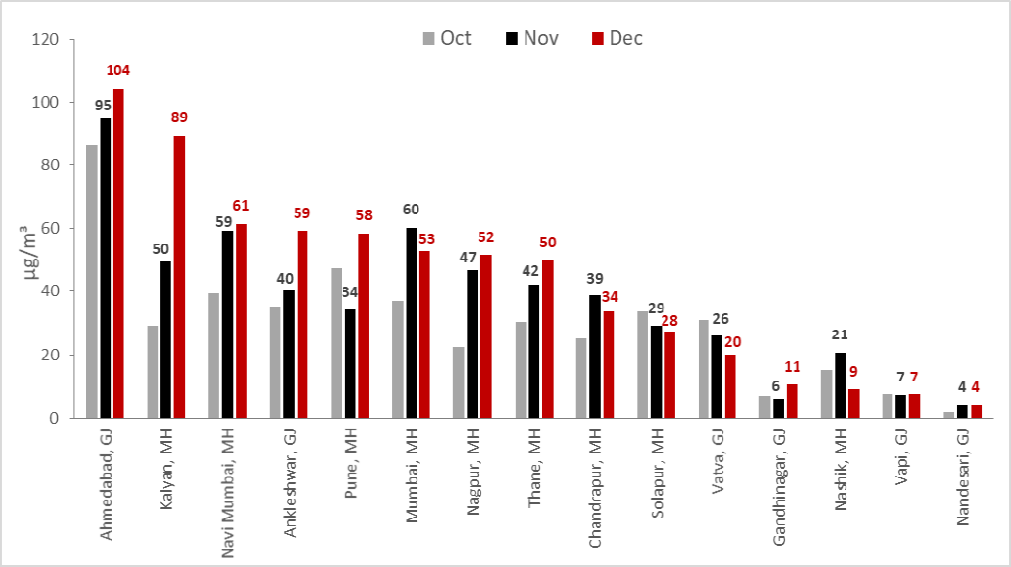
Most polluted locations are in Greater Mumbai region: There is also wide variation in pollution concentration among the monitoring locations of these states. Navi Mumbai's Sector 19A monitoring station was the most polluted location among the cities of the two states with PM2.5 averaging at 164 µg/m³. 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 the two states (See *Annex 1: PM2.5 level at station levels 1 Oct 2022-28 Feb 2023*). Surat also features among the ten most polluted location.

Multi-pollutant challenge - increasing levels of Nitrogen dioxide (NO2) during November and December: There is significant increase in amountof NO2 concentration during November and December compared to October, 2023. NO2 comes entirely fromcombustion sources and significantly from vehicles. Kalyan in Maharashtra have registered 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, Ahmedabad registered the highest NO2average of 104 µg/m³ (See *Graph 7: Trend inNO2levels in the sub-regions of the two states*). It is followed by Kalyan with 89 µg/m³ and Navi Mumbai with 61 µg/m³. The lowest NO2 level was recorded by Nadesari with 4 µg/m³ and Vapi with 7 µg/m³.

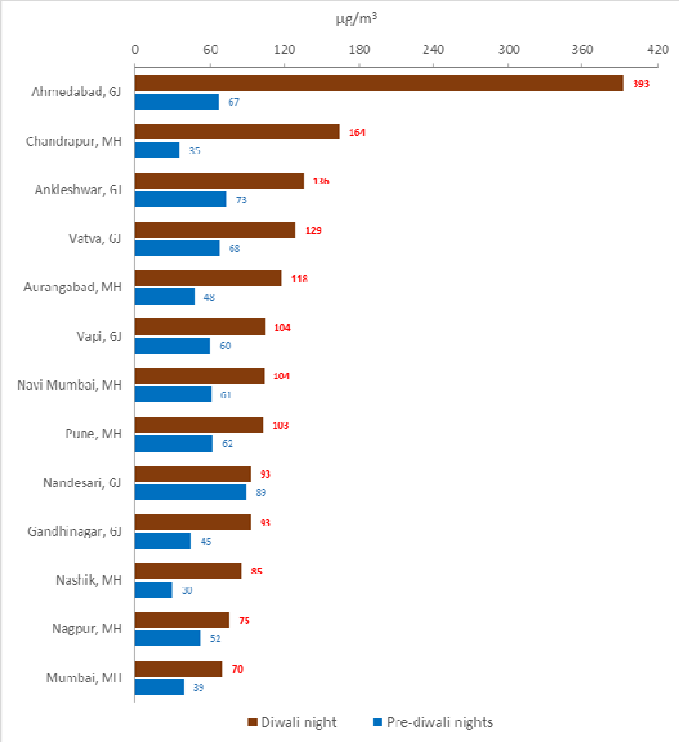
Graph7:TrendinNO2 levelsamongsub-regionsof the two states



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 for completeassessmentperiod.Data uptill31December 2022. Source:CSEanalysisofreal-timedatafromCPCBportal

Diwali pollution increased in several cities: PollutionlevelonDiwalinight(8pmto8am)in cities shot up by 1 – 5.9 times the average level recorded seven nights preceding Diwali (See *Graph 8:Diwali night pollution among cities of West India*). Ahmedabad experienced 5.9 times higher PM2.5 level on Diwalinight at 393 µg/m³. It is followed by Chandrapur in Maharashtra with 4.6 time's higher PM2.5 concentration. Mumbai and Nagpur hadtheleastpollutedDiwalinight in theregion each with 70 µg/m³ and 75 µg/m³ followed by Nashik with 85 µg/m³. (See*Graph9:TrendinDiwalinightpollution amongmajorcities ofWest India*).

Graph8:Diwali night pollution among cities



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

The rapidly growing cities of the western states of Maharashtra and Gujarat that were hitherto not so much under scanner for growing air pollution problem, are increasingly coming under the spotlight. Winter pollution is indicative of the growing local problem. As soon as the weather turns adverse with cool and calm conditions, the high local pollution gets trapped and spirals. This demands urgent and aggressive scaling up of the multi-sector action plan to control pollution from vehicles and transport, industries, open burning of waste and landfill fires, use of solid fuels in households, construction, and dust sources.

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
NaviMumbai_S19ANerul (IITM)	Maharashtra	53	164
Vapi_Ph1_GIDC	Gujarat	84	128
Mumbai_Deonar (IITM)	Maharashtra	71	123
Mumbai_BKC (IITM)	Maharashtra	74	120
NaviMumbai_Nerul	Maharashtra	82	116
Mumbai_Mazgaon (IITM)	Maharashtra	119	109
Mumbai_NavyNagar (IITM)	Maharashtra	89	104

Surat_ScienceCenter	Gujarat		103
Mumbai_Chakala (IITM)	Maharashtra	72	98
Mumbai_VileParleWest	Maharashtra	76	89
Mumbai_MulundW	Maharashtra	68	83
Mumbai_Sion	Maharashtra	57	82
Ankleshwar_GIDC	Gujarat	99	81
Nagpur	Maharashtra	38	79
Mumbai_Khindipada_IITM	Maharashtra	48	77
Chandrapur	Maharashtra	51	73
Mumbai_Powai	Maharashtra	68	71
Mumbai_KandivaliEast	Maharashtra	64	69
Vatva_Ph4_GIDC	Gujarat	70	66
Kalyan_Khadakpada	Maharashtra	85	65
Mumbai_Colaba	Maharashtra	64	63
Mumbai_BorivaliEast	Maharashtra	62	60
Mumbai_Worli	Maharashtra	71	60
Mumbai_SiddharthNagar (IITM)	Maharashtra	52	58
Aurangabad	Maharashtra	39	57
Mumbai_CSIA_T2	Maharashtra	52	57
Mumbai_VasaiWest	Maharashtra	59	57
Ahmedabad_Maninagar	Gujarat	62	56
Nashik	Maharashtra	49	55
Chandrapur_Khutala	Maharashtra	62	55
NaviMumbai_Mahape	Maharashtra	77	54
Pune_KarveRoad	Maharashtra	66	53
Mumbai_MaladW (IITM)	Maharashtra	43	48
Nandesari_GIDC	Gujarat	32	47
Gandhinagar_S10	Gujarat	40	45
Solapur	Maharashtra	45	45
Mumbai_Kurla	Maharashtra	79	39

Note: October- Februaryaverage is based on mean of daily averages. All values are in $\mu g/m^3$.
Source: CSE analysis of CPCB real-time data

PART 2

West India's winter pollution problem: A growing concern
Part II: Winter pollution in major cities of West India
AnumitaRoychowdhury, AvikalSomvanshi and Sharanjeet Kaur

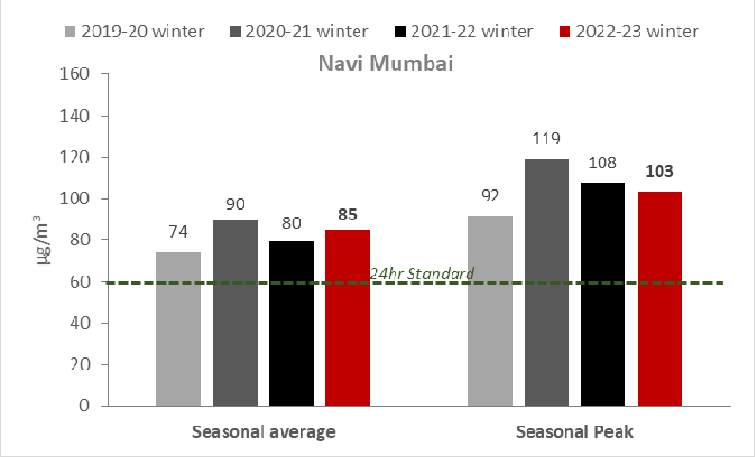
Centre for Science and Environment, New Delhi, March, 2023

Note: This does not include Mumbai as it has been covered in the mega-cities analysis that was published earlier. One can access that analysis here (https://www.cseindia.org/APC-Winter-Cities-other-than-Delhi-NCR-NOTE.pdf)

Maharashtra: NaviMumbai

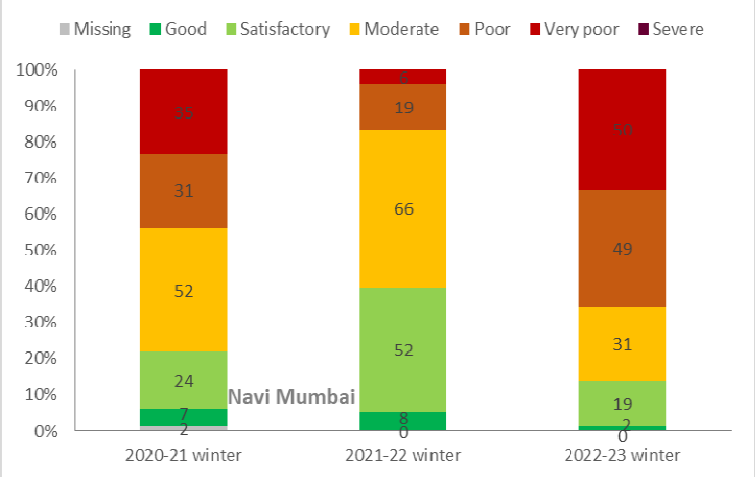
Winter pollutionlevel in Navi Mumbai this season has been 5 per cent higher than the mean of previous three winters and is considerably higher than the standard. But there has been 3 per cent decline in winter peak compared to the mean of peaks of previous of three winters (See*Graph10:PM2.5wintertrendinNavi Mumbai*). 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 going from 25 to 99 bad days (See*Graph11: PM2.5 AQItrendinNavi Mumbai*).

Graph10:PM2.5wintertrendinNavi Mumbai



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

Graph11: PM2.5AQItrendin Navi Mumbai



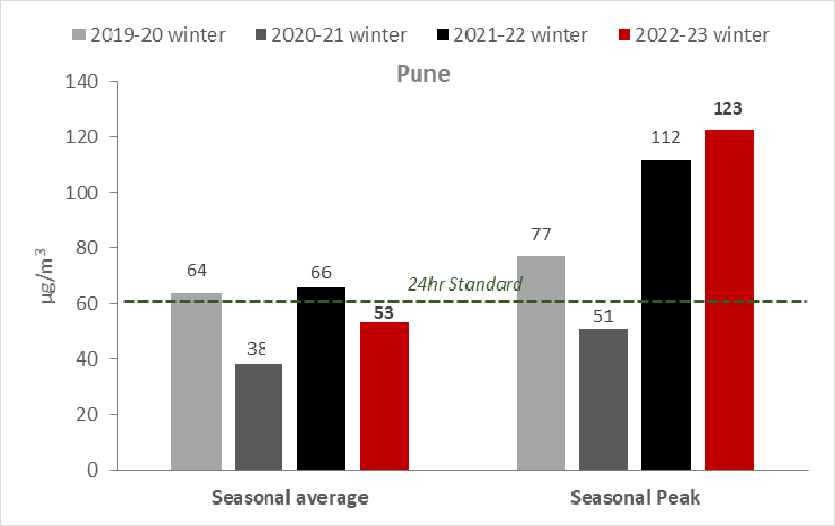
Note:PM2.5valueisbasedonstationsthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly. Winter is defined as 1 October -28 February. Source:CSEanalysisofreal-timedatafromCPCBportal

Maharashtra: Pune

Winter pollutionlevel in Pune this season has been 5 per cent lower than the mean of previous three winters. However, there has been drastic increase in winter peak with 53 per cent compared to the mean of peaks of previous of three winters, highest in all past four winters. (See*Graph12:PM2.5wintertrendinPune*).

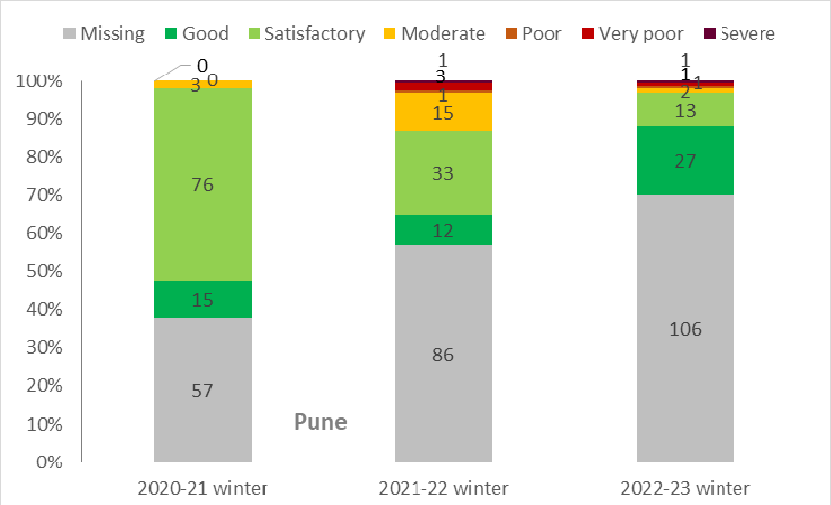
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated to 1 severe day this winter. But due to large number of missing data, accurate air quality days cannot be observed. Otherwise there would be more severe or bad days in the city. (See*Graph13: PM2.5 AQItrendinPune*).

Graph12:PM2.5wintertrendinPune



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

Graph13: PM2.5AQItrendinPune



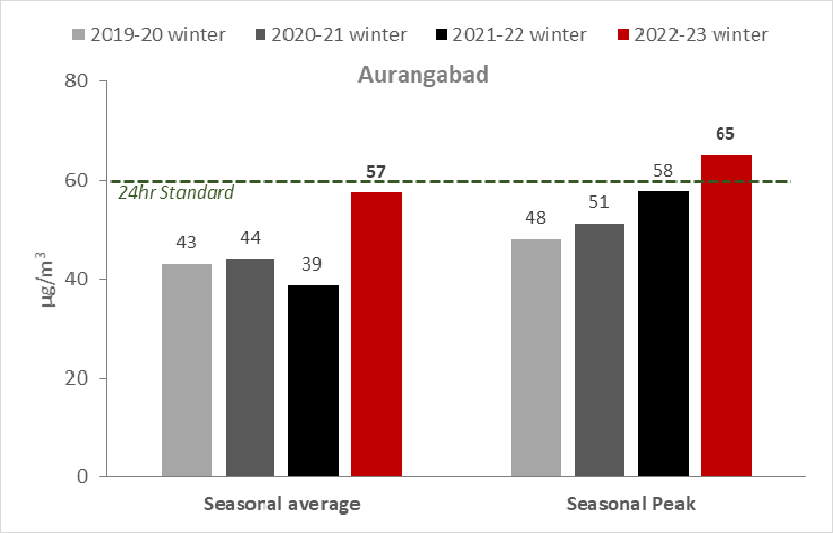
Note:PM2.5valueisbasedonstationsthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Maharashtra: Aurangabad

Winter pollutionlevel in Aurangabad this season has been 37 per cent higher than the mean of previous three winters and with seasonal average of 57 µg/m³ the city's air quality is considerably higher than the last three winters. Similarly, there has been 24 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph14: PM2.5wintertrendin Aurangabad*).

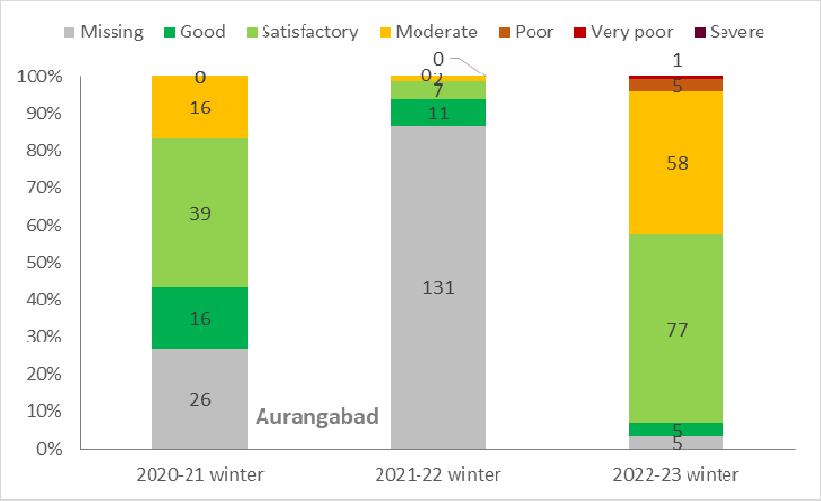
AQIcategorizationofday'sshowsthatthecity'sairquality has not deteriorated to severe airquality and had 6 days of very poor and poor air quality, a considerable increase compared to previous two winters(See *Graph 15: PM2.5 AQI trend in Aurangabad*). However, the number of good days are also decreasing this winter.

Graph14:PM2.5wintertrendinAurangabad



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

Graph15:PM2.5AQItrendinAurangabad



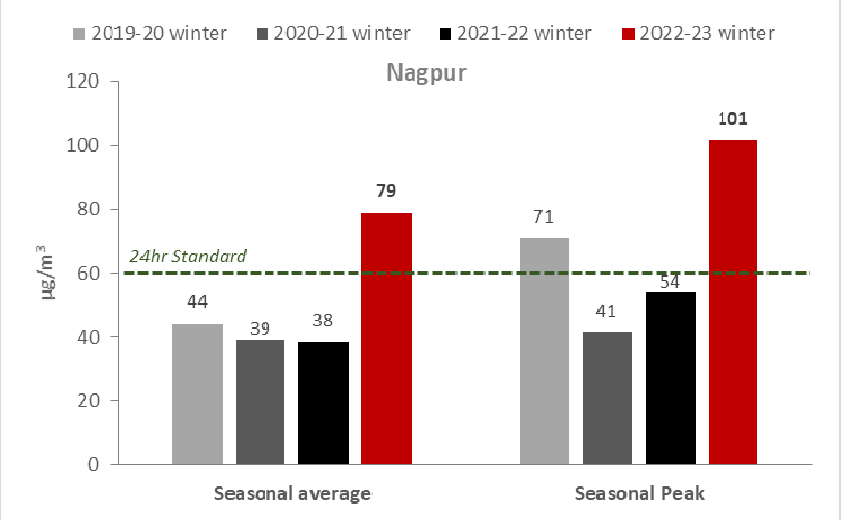
Note: PM2.5 value is based on station that have continuous and adequate data for complete assessment period. AQI is based onPM2.5sub-categoryonly.Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Maharashtra: Nagpur

Winter pollutionlevel in Nagpur this season has been 94 per cent higher than the mean of previous three winters and with seasonal average of 79 µg/m³ the city's air quality is considerably higher than the standard. Similarly, there has been 83 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph16: PM2.5wintertrendin Nagpur*).

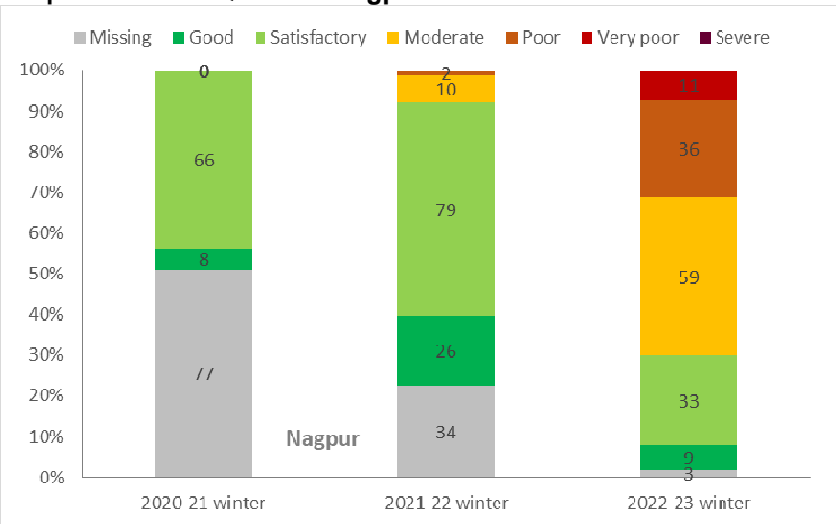
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated considerably this winter with 47 days of very poor and poor air quality, a considerable increase compared to previous two winters(See *Graph 17: PM2.5 AQI trend in Nagpur*). There were only 2 "poor" days in 2021-22 winter and zero "very poor" and "poor" days in 2020-21 winter.

Graph16:PM2.5annualandwintertrendinNagpur



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

Graph17:PM2.5AQItrendinNagpur



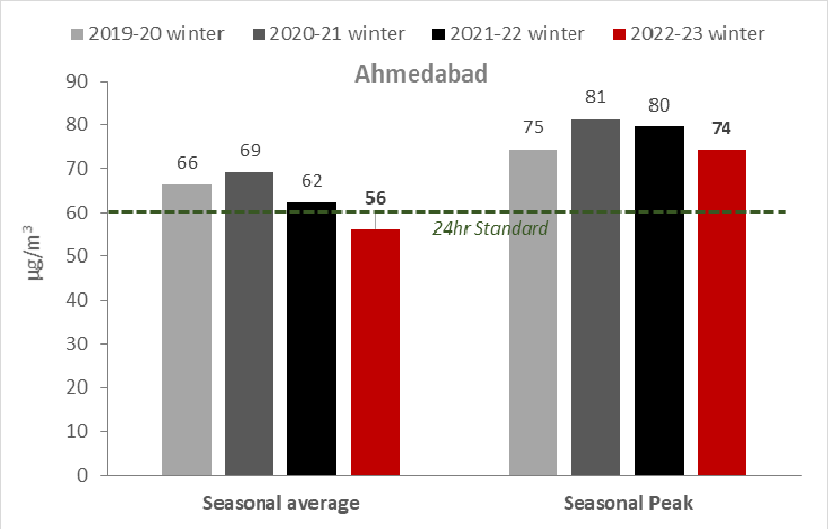
Note: PM2.5 value is based on station that have continuous and adequate data for complete assessment period. AQI is based onPM2.5sub-categoryonly.Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Gujarat: Ahmedabad

Winter pollutionlevel in Ahmedabad this season has been 10 per cent lower than the mean of previous three winters and with seasonal average of 56 µg/m³, considerably lower than the last three winters average. Similarly, there has been 5 per cent decrease in winter peak compared to the mean of peaks of previous of three winters (See*Graph18:PM2.5wintertrend in Ahmedabad*).

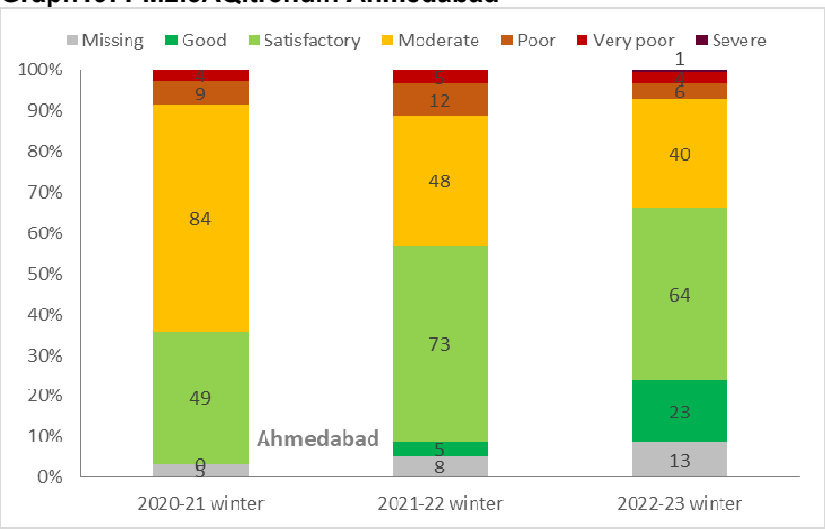
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated this winter with 1 day of severe airquality in last three years. The city had 10 days of very poor and poor air quality, a considerable decrease compared to previous two winters(See *Graph 19: PM2.5 AQI trend inAhmedabad*). There were 17 bad days in 2021-22 winter and 13 bad days in 2020-21 winter.

Graph18: PM2.5wintertrendin Ahmedabad



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

Graph19: PM2.5AQItrendin Ahmedabad



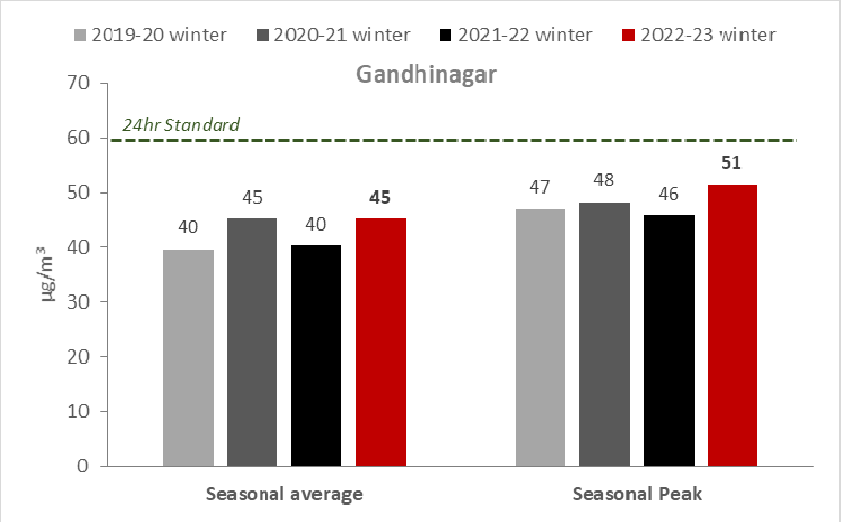
Note:PM2.5valueis basedonstationthathavecontinuousandadequatedataforcompleteassessmentperiod.AQIis basedonPM2.5sub-categoryonly. Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Gujarat: Gandhinagar

Winter pollutionlevel in Gandhinagar this season has been 8 per cent higher than the mean of previous three winters and with seasonal average of 45 µg/m³ the city's air quality is almost consistent in the city from last three winters. Similarly, there has been 10 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph20: PM2.5wintertrendin Gandhinagar*).

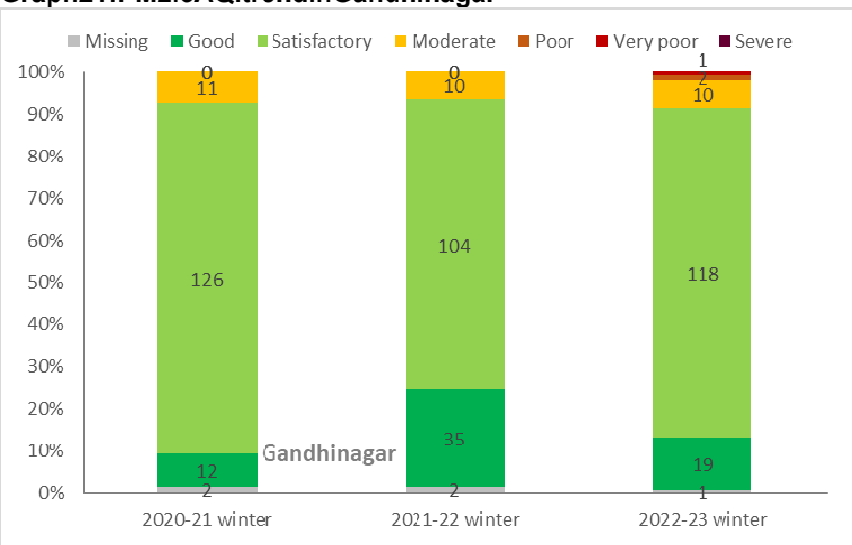
AQIcategorizationofday'sshowsthatthecity'sairquality has deteriorated with 3 days of very poor and poor air quality, which was zero in previous two winters(See *Graph 21: PM2.5 AQI trend in Gandhinagar*). The number of good air days are decreasing the winter compared to last winter, going from 35 to 19 good days.

Graph20:PM2.5annualandwintertrendinGandhinagar



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

Graph21:PM2.5AQItrendinGandhinagar



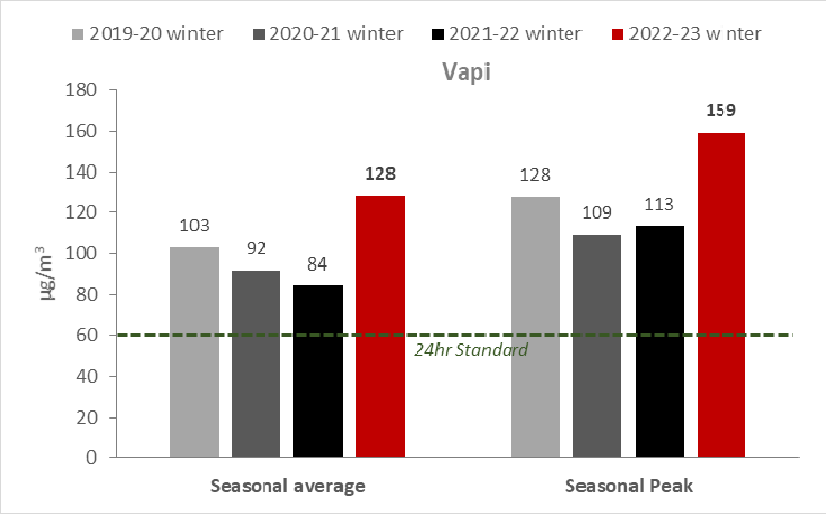
Note: PM2.5 value is based on station that have continuous and adequate data for complete assessment period. AQI is based onPM2.5sub-categoryonly.Winter is defined as 1 October -28 February.
Source:CSEanalysisofreal-timedatafromCPCBportal

Gujarat: Vapi

Winter pollutionlevel in Vapi this season has been 38 per cent higher than the mean of previous three winters and with seasonal average of 128 µg/m³, higher than the last three winters average. Similarly, there has been 36 per cent increase in winter peak compared to the mean of peaks of previous of three winters (See*Graph22:PM2.5wintertrend in Vapi*).

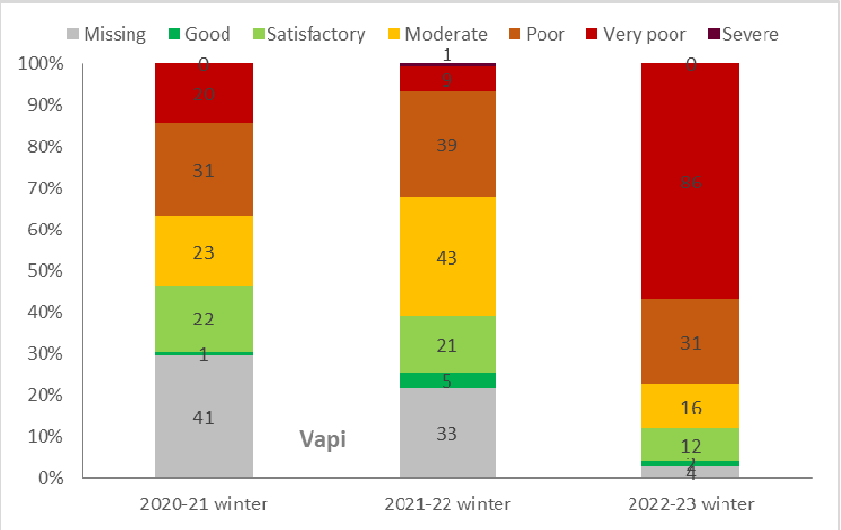
AQIcategorizationofday'sshowsthatthecity'sairquality has not deteriorated this winter with severe airquality. However the city had tremendous increase in "very poor" and "poor" air quality with 117 days, compared to previous two winters(See *Graph 23: PM2.5 AQI trend inVapi*). There were 48 bad days in 2021-22 winter and 51 bad days in 2020-21 winter.

Graph22: PM2.5wintertrendin Vapi



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

Graph23: PM2.5AQItrendin Vapi



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