Tracking overall and winter air pollution in the southern region -- cities of Andhra Pradesh, Kerala, Karnataka, Tamil Nadu and Telangana

Anumita Roychowdhury, Avikal Somvanshi and Sharanjeet Kaur

Centre for Science and Environment, New Delhi, January 19, 2022

Even though the states in the southern region of India have some of the cleanest cities in the country, it still comes under some influence of winter inversion and elevated pollution levels. The levels increase despite the geographical advantages and favorable meteorology due to its proximity to the sea and improved ventilation. At the same time the annual average level of PM2.5 that was downward in 2020 has risen again in most cities of the southern states during 2021. This has emerged from the recent air quality analysis of the Centre for Science and Environment (CSE) for the period 2019-2021.

However, unlike the states in other regions, the air quality gains are not completely lost. In most cities the levels are still lower than 2019. This signals towards early preventive action to prevent further worsening in the coming years. This requires urgent scaling up of across all sectors to arrest the trend in this region.

Even though real time air quality monitoring has begun to expand in these states to provide more up to date and real time information on air quality, there are serious concerns around missing data and gaps that makes proper risk assessment difficult. In some stations of Karnataka, Hyderabad and Tamil Nadu, data availability is so low that the trend cannot be assessed. Quality control of data is necessary.

This is evident from the new analysis of real time pollution data as part of the air quality tracker initiative of the Urban Data Analytics Lab of CSE. The objective of this new analysis is to understand the trend and magnitude of pollution in different regions that have real time air quality monitoring systems. This is an assessment of annual and seasonal trends in PM2.5 concentration for the period 1st January 2019 to 9th January 2022. This analysis is based on the real time data available from the current working air quality monitoring stations. 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 63 continuous ambient air quality monitoring stations (CAAQMS) spread across 39 cities in five states and a union territory: Andhra Pradesh -- one station each in Amravati, Tirupati, Vijaywada, Rajamahendravaram, and Visakhapatnam; Kerela -- three stations in Kochi, two stations in Thiruvananthapuram, and one station each in Kollam, Kannur, Kozhikode, and Thrissur; Karnataka -- ten stations in Bengaluru and one station each in Bagalkot, Bidar, Chamarajanagar, Chikkaballapur, Chikkamagaluru, Davanagere, Gadag, Hassan, Hubballi, Kalaburagi, Kolar, Koppal, Madikeri, Mangalore, Mysuru, Raichur, Ramnagara, Shivamogga, Udupi, Vijaypura, and Yadgir; Tamil Nadu -- eight stations in Chennai, and one station each in Coimbatore, Gummidipoondi, and Thoothukudi; Telangana – six stations in Hyderabad; Puducherri – one station at Pondicherry.

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. Moreover, in several cases the real time monitors have been set up recently and therefore long term data is not available. Several cities of southern region have got their real time monitors in November 2020. Chennai got 4 out of their 8 real time monitors only in Jan 2021. Vijaywada station stopped reporting PM2.5 data after October 2019, and Sanegurava Halli station in Bengaluru stopped reporting PM2.5 data early 2019.

Summary highlights of key findings

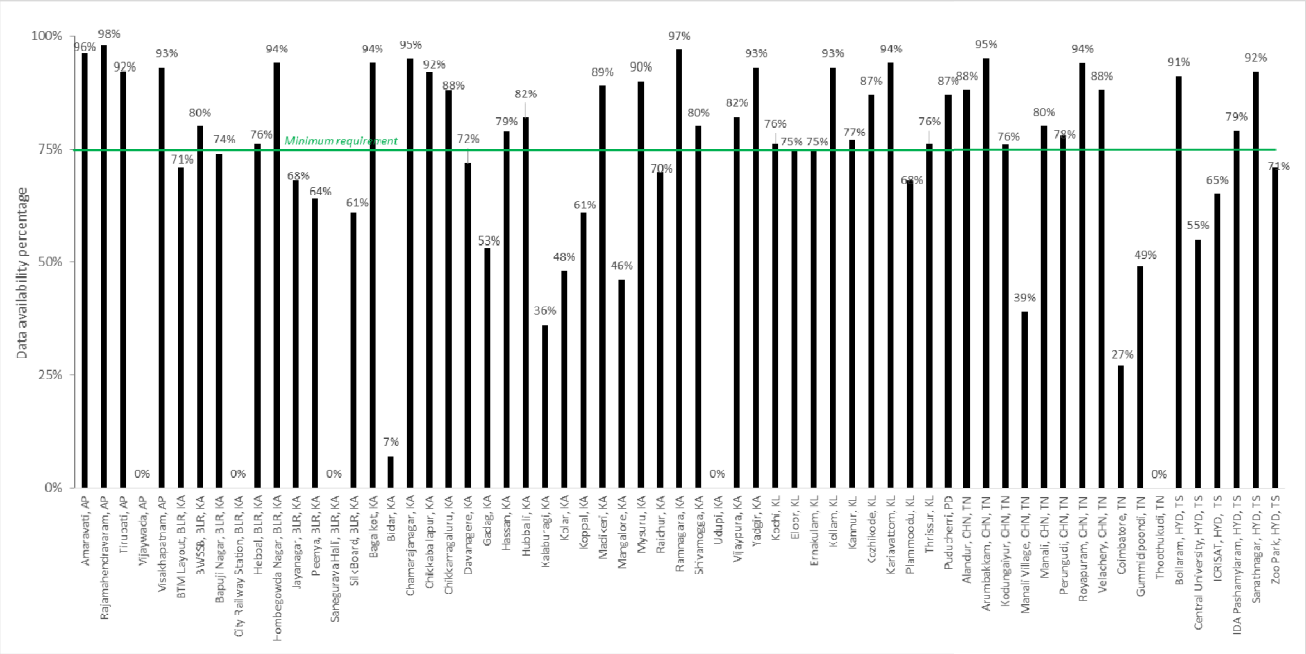
Challenge of data gaps and data quality despite automation in Tamil Nadu and Karnataka, situation relatively better in Andhra Pradesh, Telengana and Kerela: Review of data availability from the automated monitoring stations in the region under Continuous Ambient Air Quality Monitoring Stations (CAAQMS) program of CPCB, shows major data gaps. Data availability calculated as number of days with adequate PM2.5 data for computation of a valid

24hr-average has been low in 19 of 39 cities in the region. For the second half of the year 2021 (June to December) data availability at Vijaywada station of Andhra Pradesh, City Railway Station and Sanegurava Halli stations of Bengaluru, Thoothukudi station of Tamil Nadu, and Udupi station of Karnataka has been zero per cent. Coimbatore station of Tamil Nadu, Kalaburagi station and Bidar station of Karnataka has just 27 per cent, 39 per cent, and 7 per cent data availibility respectively. Velachery and Manali Village stations of Chennai also reported data only for 27 per cent and 36 per cent of days respectively.

Among Bengaluru stations, Silk board has only 61 per cent data while Peenya and Jayanagar with 64 per cent and 68 percent. Gummidipoondi station of Tamil Nadu and Central University of Hyderabad are data poor as well with 49 per cent and 55 per cent data availability respectively. Only twelve out of twenty one stations of Karnataka outside Bengaluru meet the minimum requirement of 75 per cent (See Graph 1: Data availability at real time monitoring stations of South India region in June-Dec, 2021). It is not clear why these stations have such poor data availability, this requires additional assessment which is not in the scope of this study.

In contrast most stations of Andhra Pradesh and Kerala perform better as they have data availability of more than 75 per cent. Only station at Plammoodu in Thiruvananthapuram, Kerala is below the minimum 75 per cent data availability requirement.

Graph 1: PM2.5 data availability at real time monitoring stations of South India for June-Dec, 2021



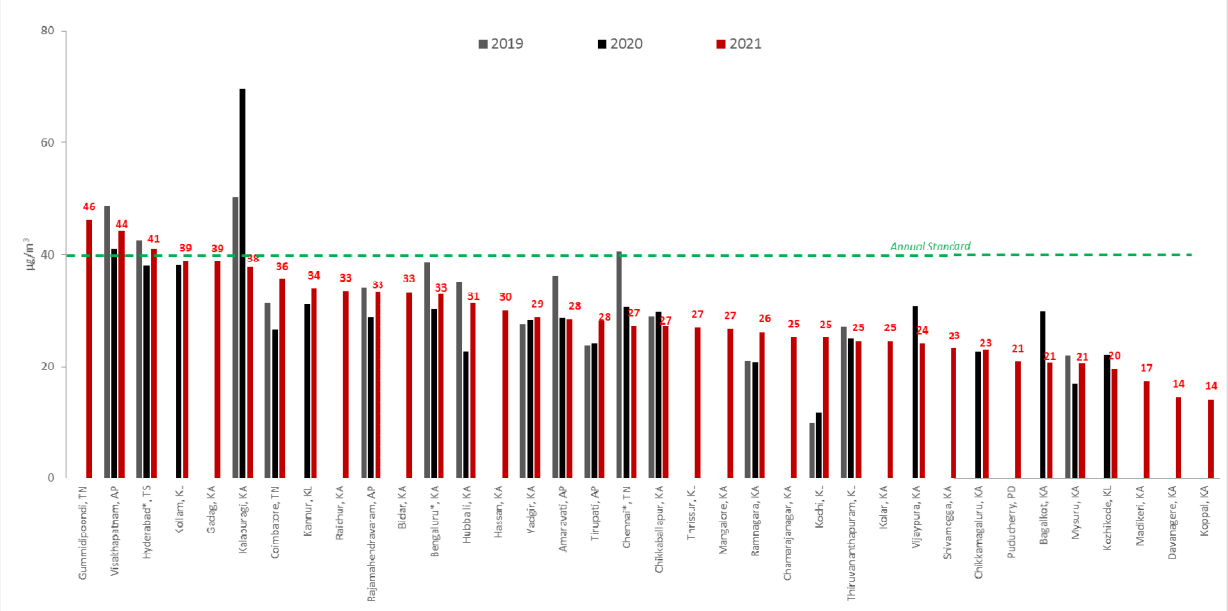
Source: CSE analysis of real time data from CPCB website

Many cities show a rising trend in annual PM2.5 level after an initial drop during 2020 with more pandemic related lockdown phases: Among all the regions, cities of South India have shown least of a rebound and a rising trend once again in 2021 after significant drop due to maximum pandemic lockdowns of 2020. But there is still a rebound and it should be seen as a warning signal. 22 cities have adequate data for both 2020 and 2021 for annual average computation. 16 of these cities show increase in their annual PM2.5 average while six show further improvement. Kochi has registered doubling of its annual PM2.5 average between 2020 and 2021. Cities that show improvement are Chennai, Kalaburagi, Chikkaballapur, Vijaypura, Chikkmangaluru, and Kozhikode.

Industrial town Gummidipoondi near Chennai in Tamil Nadu, had the most polluted air in the region with 2021 average at 46 ug/m3. This is followed by Visakhapatnam and Hyderabad with 2021 annual average of PM2.5 at 44 ug/m3 and 41 ug/m3 respectively (See Graph 2: PM2.5 trend among cities of South India states 2019-2021). In contrast, all other cities in the southern region

have met the annual standard with average.

Graph 2: Long term PM2.5 trend among cities of South India states (2019-2021)

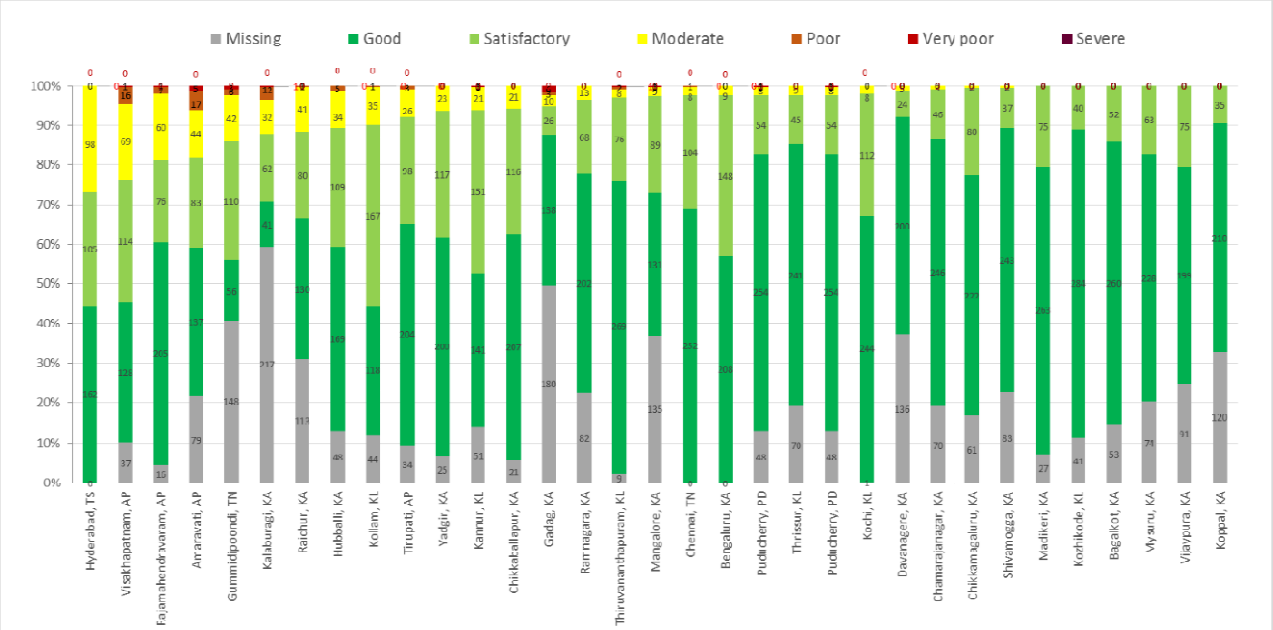


Note: PM2.5 values for cities with more than one monitoring stations is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

Cities of Andhra Pradesh and Telangana have worst air among the Southern states: Hyderabad with 98 days of bad air (AQI of moderately polluted or worse) is the city with most unhealthy days in Southern states. It is closely followed by Andhra cities; Visakhapatnam with 86 days, Rajamahendravaram with 68 days, and Amravati with 66 days of bad air. Smaller industrial towns of Karnataka namely Gadag and Kalaburagi also report significant bad air days, in fact AQI in these cities can cross into very poor AQI category but due to massive amount of missing data it is unclear how long these bad air episodes actually last. Gummidipoondi has the most bad air days in Tamil Nadu while Kollam in Kerela (See Graph 3: PM2.5 based AQI categorization of days for major cities in South Indian states – 2021).

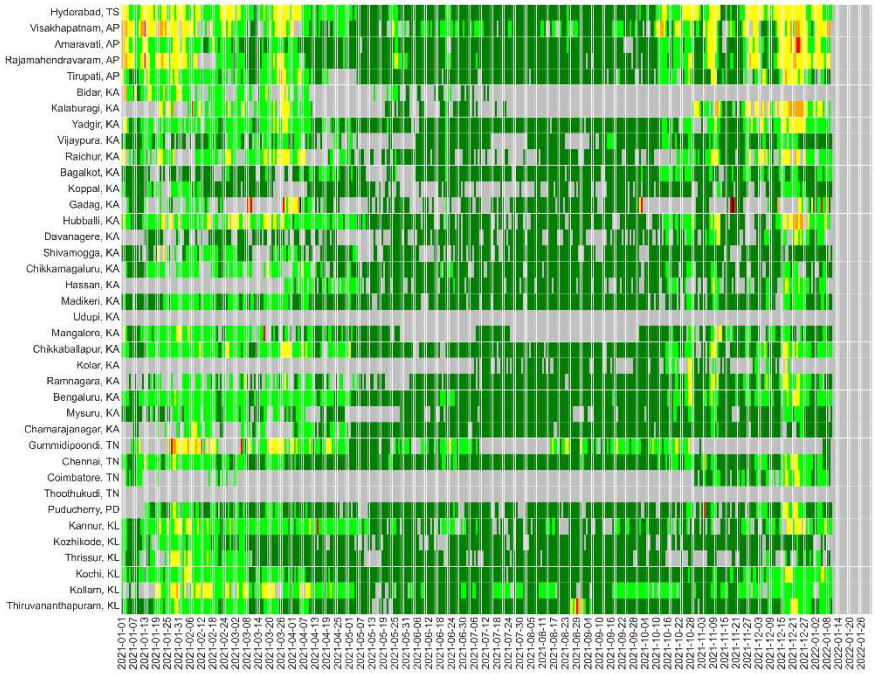
Bad air days begin to build up around the end of December in the cities of south Indian states and tend to increase till end of March. Hyderabad and cities in the Andhra Pradesh show more pronounced impact of winter pollution compared to other cities of the region (See Graph 4: Heatmap based on days classified as per PM2.5 air quality index for major cities of South Indian states).

Graph 3: PM2.5 based AQI categorization of days for major cities in South Indian states 2021 – (Percentage share and number of days)



Note: PM2.5 values for cities with more than one monitoring stations is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

Graph 4: Heatmap based on days classified as per PM2.5 air quality index for major cities of South Indian states

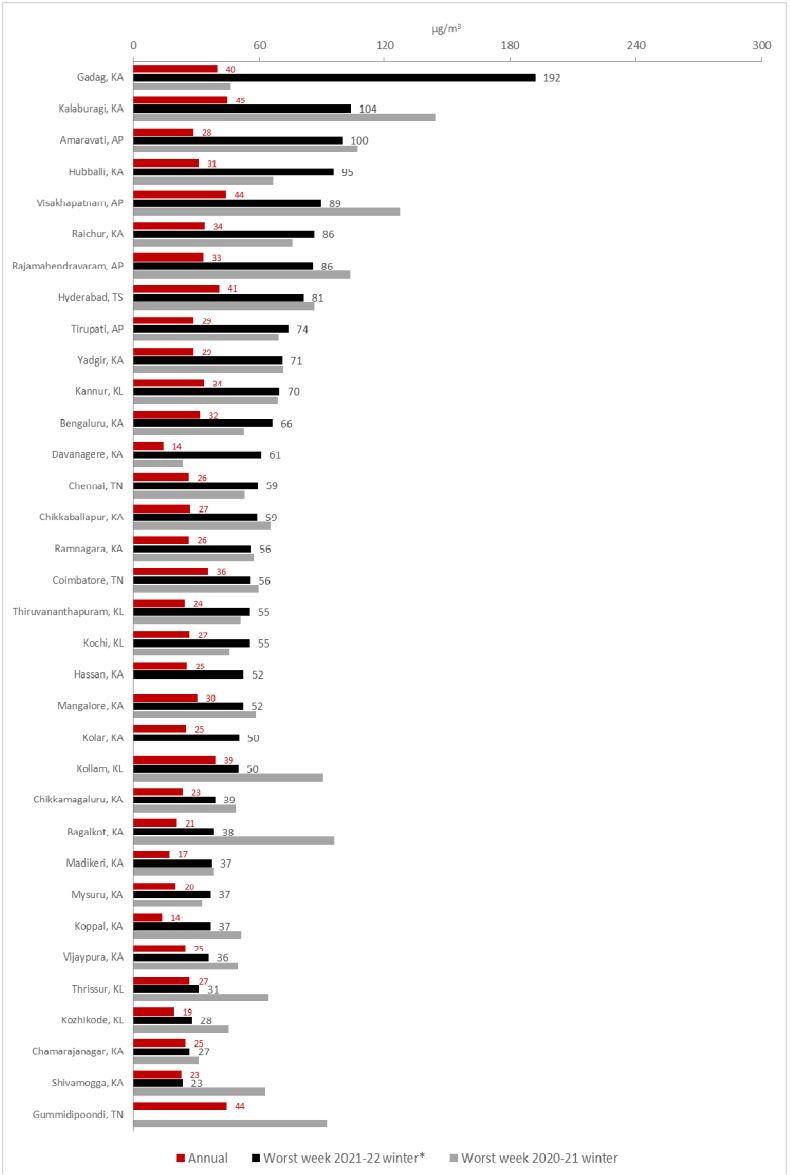


Note: PM2.5 values for cities with more than one monitoring stations is based on average of all stations that have continuous and adequate data for complete assessment period. Cell colors are based on the official AQI category colors. Data up till 9 January 2022. Source: CSE analysis of real time data from CPCB portal

High weekly pollution episode during winter can be more than double the annual concentration in several cities: During the worst weekly pollution episode in winter the PM2.5 concentration can increase significantly higher than the annual PM2.5 average – about two times high in several cities. Worst episodes are noted in the industrial towns of Karnataka where Gadag registered a shocking weekly average of 192 ug/m3 (almost five times its annual average). Similarly, Kalaburagi recorded a weekly average of 104 in mid-December.

Among non-industrial cities, during the high pollution episodes weekly PM2.5 levels can go as high as 100 ug/m3 as recorded in Amravati in December 2021 (See Graph 5: Weekly PM2.5 levels vs annual level among in cities of South Indian states). This winter so far the highest weekly level has recorded 95 ug/m3 in Hubbali, 89 ug/m3 in Visakhapatnam, 86 ug/m3 in Rajamahendravaram, and 81 ug/m3 in Hyderabad.

Graph 5: Comparison of worst weekly PM2.5 levels with annual average level in Cities of South Indian states



Note: Worst week for Amravati were weeks ending on 26 Dec 2021 and 27 Dec 2020; Hubbali were weeks ending on 26 Dec 2021 and 27 Dec 2020; Visakhapatnam were weeks ending on 26 Dec 2021 and 27 Dec 2020; Rajamahendravaram were weeks ending on 26 Dec 2021 and 3 Jan 2021. Hyderabad were weeks ending on 26 Dec 2021 and 3 Jan 2021; Tirupati were weeks ending on 26 Dec 2021 and 27 Dec 2020. Worst week for Yadgir were weeks ending on 26 Dec 2021 and 3 Jan 2021; Kannaur were weeks ending on 26 Dec 2021 and 27 Dec 2020; Bengaluru were weeks ending on 26 Dec 2021 and 31 Jan 2021; Chennai were weeks ending on 26 Dec 2021 and 27 Dec 2020. Chikkaballapur were weeks ending on 26 Dec 2021 and 24 Jan 2021; Ramnagara and were weeks ending on 26 Dec 2021 and 1 Nov 2020; Kochi were weeks ending on 19 Dec 2021 and 31 Jan 2021; Thiruvananthapuram were weeks ending on 26 Dec 2021 and 31 Jan 2021; Kollam were weeks ending on 2 Jan 2022 and 1 Nov 2020; Chikkamagaluru were weeks ending on 26 Dec 2021 and 1 Nov 2020; Bagalkot and were weeks ending on 9 Jan 2022 and 1 Nov 2020; Mysuru were weeks ending on 26 Dec 2021 and 1 Nov 2020; Vijaypura were weeks ending on 19 Dec 2021 and 8 Nov 2020; Thrissur were weeks ending on 12 Dec 2021 and 31 Jan 2021; Kozhikode were weeks ending on 9 Jan 2022 and 27 Dec 2020. Data up till 9 January 2022.
Source: CSE analysis of real time data from CPCB portal

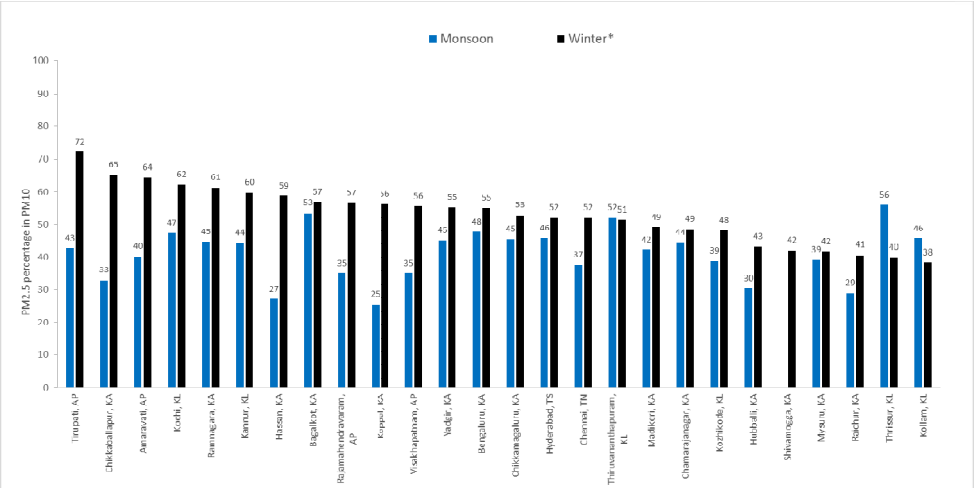
Changing ratio of PM2.5:PM10 during different seasons of 2021 – PM2.5 share increase during winter making air more toxic: The PM2.5/PM10 ratio is a useful indicator to understand the impact of coarse dust vs tinier dust from combustion sources on air quality. Higher share of

smaller particles in total particle concentration makes the air more toxic. The indicative ratio for all cities show there is a seasonal variation. The share of smaller PM2.5 is higher than the coarser PM10 in monsoon and winter. The long-term variation of the PM2.5/PM10 ratio was analyzed from weekly data average for two different seasons: Monsoon (June - October) and winter (November – January). (See Graph 6: Changing ratio of PM2.5:PM10 during different seasons of 2021).

The PM2.5/PM10 ratio in all the cities of southern states has an increasing slope in winters comparing to monsoon except Thrissur and Kollam in Kerela, which is showing high percentage of PM2.5/PM10 ratio in monsoon compared to winter. Mostly, the concentration of PM2.5/PM10 ratio is higher during winter's months (November to January) hovering between 50 to 70 per cent. This is indicative and there can be variation across years. However, this trend is broadly consistent with what has been noted in other regions of the country.

In Andhra Pradesh, Tirupati is showing high percentage of PM2.5/PM10 ratio in winters with 72 percent. It is followed by Chikkaballapur in Karnataka with 65 percent. Kochi in Kerala with 62 percent. Overall in southern India region, the concentration of PM2.5/PM10 ratio is higher during winter (November to January) (See Graph 6: Changing ratio of PM2.5:PM10 during different seasons of 2021).

Graph 6: Changing ratio of PM2.5:PM10 during different seasons of 2021

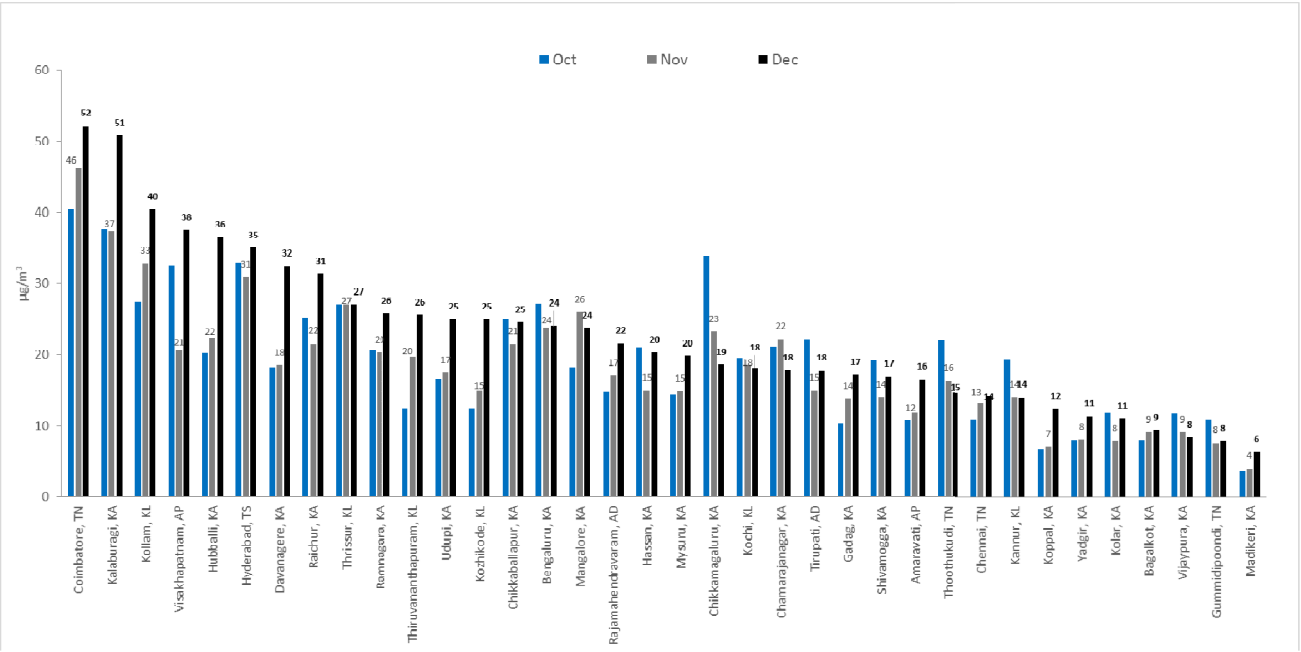


Note: Average PM2.5 concentration for a week is based on mean of all CAAQM stations in the city. Data up till 9 January 2022. Source: CSE analysis of CPCB's real time air quality data

Nitrogen oxide (NO2) that comes largely from vehicles increase during winter: There is a significant increase in amount of nitrogen dioxide (NO2) in air of all cities of southern states during December compared to the previous months of November, October and September in most cities of South India. Coimbatore with 52 µg/m3 monthly NO2 average for December is the highest in the region. It is followed by Kalaburagi (51 µg/m3), Kollam (40 µg/m3), and Visakhapatnam (38 µg/m3).

As for the seasonal increase in NO2 concentration smaller cities led the list. Kalaburagi registered 5.8 times jump in monthly NO2 level, Thoothukudi registered a 4 times increase, while Kozhikode with 3.8 times increase, Hubballi with 3.3 times increase, and Thiruvananthapuram registered a 2.2 times increase (See Graph 7: Monthly trend in nitrogen dioxide levels in cities of Southern states).

Graph 7: Monthly trend in nitrogen dioxide levels in cities of South Indian states

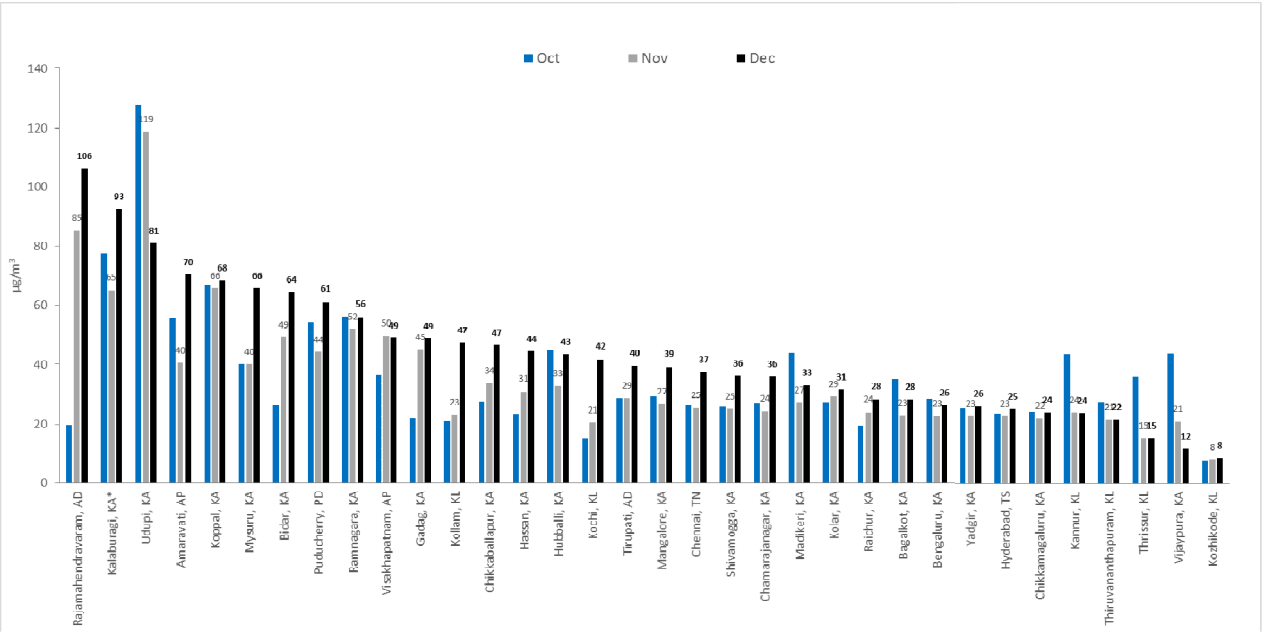


Note: NO2 values for cities with more than one monitoring stations is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021. Source: CSE analysis of real time data from CPCB portal

Surface ozone increase during winter making air more toxic: There is a significant increase in amount of surface ozone (O3) in air of all cities of western states during December compared to the previous months of November, October and September in most cities in the South. Rajamahendravaram with 106 µg/m3 monthly O3 average for December is the highest in the region. Which means ozone exceeded the standard in the city on almost everyday of December. It is followed by Kalaburagi (93 µg/m3), Udipi (81 µg/m3), and Amravati (70 µg/m3). The problem is especially acute among smaller cities (See Graph 8: Monthly trend in ozone levels in cities of South Indian states).

It is also interesting to note that surface ozone has been relatively lower this winter compared to previous winter for almost all cities.

Graph 8: Monthly trend in nitrogen dioxide levels in cities of South Indian states



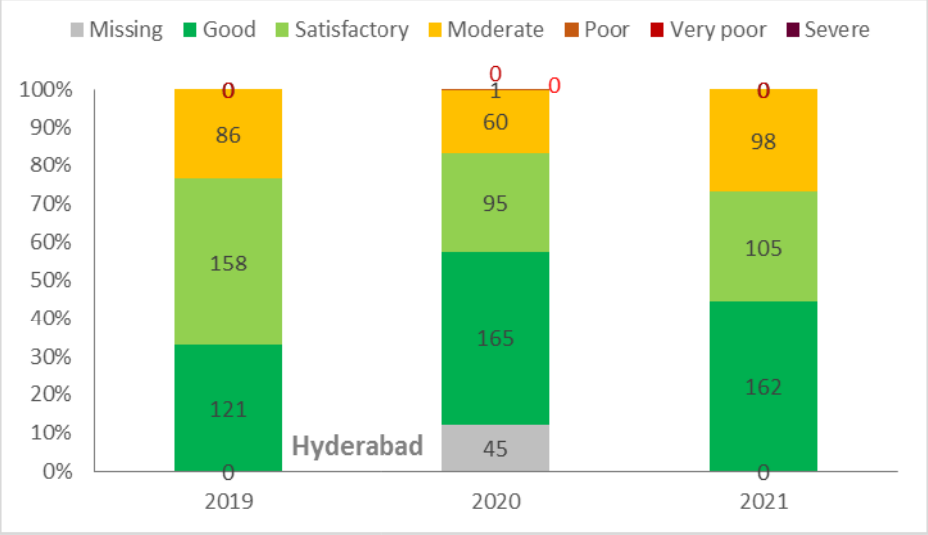
Note: Surface ozone values for cities with more than one monitoring stations is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021. Source: CSE analysis of

real time data from CPCB portal

Pollution profile of individual cities

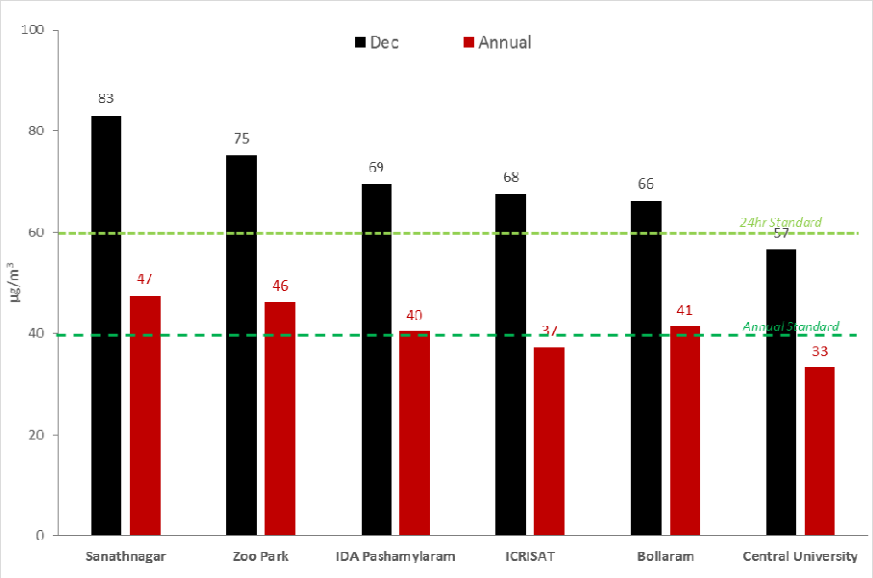
Hyderabad: Analysis of days as per AQI categorisation shows that the Hyderabad city's air quality is declining. Number of days recording AQI level worse than satisfactory has increased to 98 days in 2021 from 60 days in 2020 and 86 days in 2019 (See Graph 9: PM2.5 AQI trend in Hyderabad). In Hyderabs, the location Sanathnagar is worst air with its December average hitting 83 ug/m3. Ths is followed by Central University at 57 ug/m3 monthly average for December (See Graph 10: Variation in PM2.5 level among city stations of Hyderabad).

Graph 9: PM2.5 AQI trend in Hyderabad



Note: PM2.5 values is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

Graph 10: Variation in PM2.5 level among city stations of Hyderabad

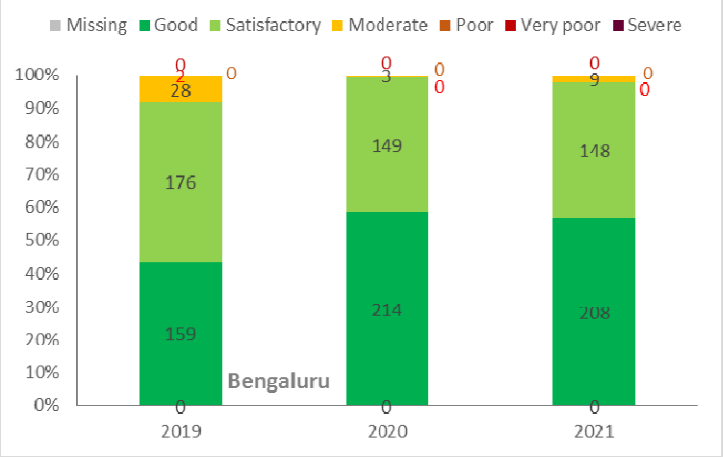


Source: CSE analysis of real time data from CPCB website

Bengaluru: Analysis of days as per AQI categorisation shows that Bengaluru city has been able to hold on to most of air quality gains made during 2020 with most hard lockdown days. The number of days with the AQI worse than satisfactory (or meeting the standard) was 9 in 2021; this is more than 3 days in 2020 and much less than 22 days in 2019 (See Graph 11: PM2.5 AQI trend in

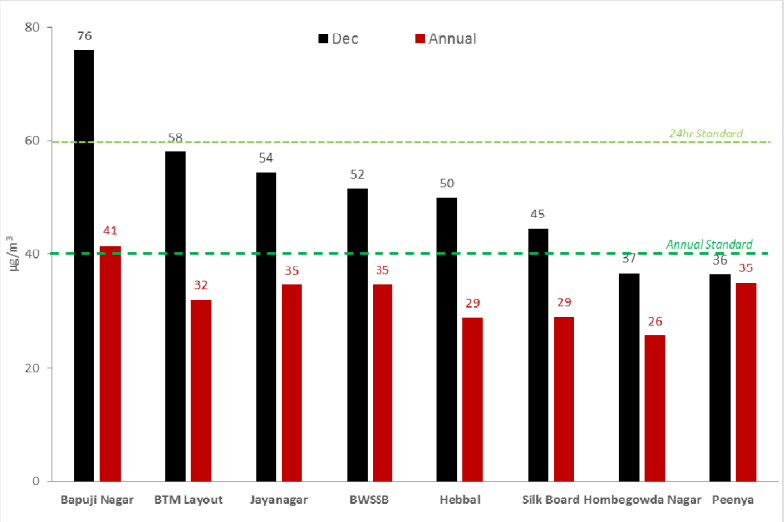
Bengaluru). Number of “good” AQI days in 2021 stood at 208 days, which is just marginally lower from 214 good AQI days recorded in 2020. It is an improvement of over 30 per cent from 2019. Within the city Bapuji Nagar was the worst hit with its December average recording 76 ug/m3. Pennya has least polluted air with 36 ug/m3 monthly average for December (See Graph 12: Variation in PM2.5 level among city stations of Bengaluru).

Graph 11: PM2.5 AQI trend in Bengaluru



Note: PM2.5 values is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

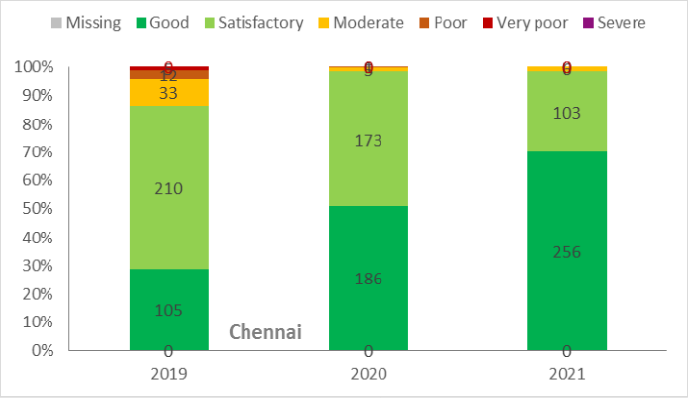
Graph 12: Variation in PM2.5 level among city stations of Bengaluru



Source: CSE analysis of real time data from CPCB website

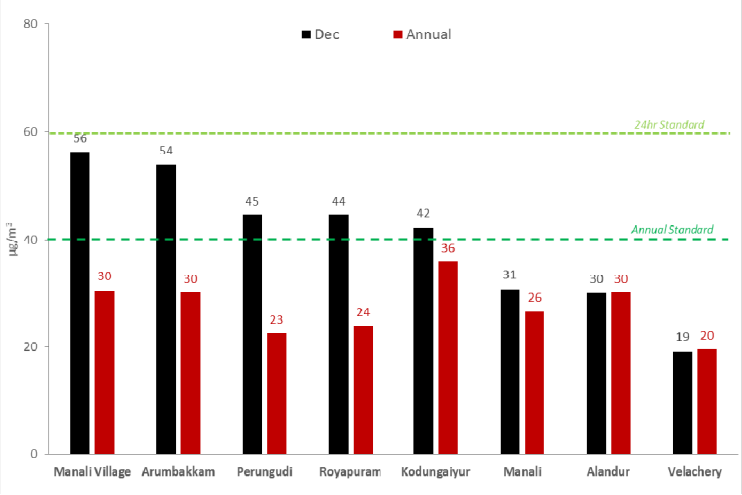
Chennai: Analysis of days as per AQI categorisation shows that the Chennai city has been able to hold on to most of air quality gains during 2020 with maximum lockdown days. Number of days when the AQI was worse than satisfactory was 6 in 2021, same as 2020. But 2019 had witnessed 50 days (See Graph 13: PM2.5 AQI trend in Chennai). Within the city, Manali Village has the worst air with its December average adding up to 56 ug/m3 closely followed by Arumbakam with 54 ug/m3. Velachery has least polluted air with 19 ug/m3 monthly average for December (See Graph 14: Variation in PM2.5 level among city stations of Chennai).

Graph 13: PM2.5 AQI trend in Chennai



Note: PM2.5 values is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

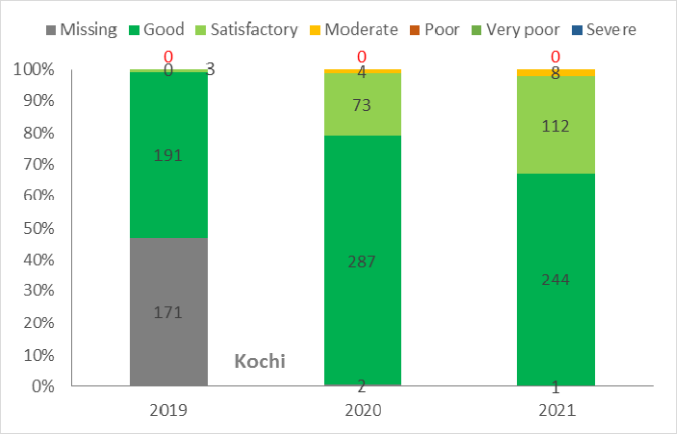
Graph 14: Variation in PM2.5 level among city stations of Chennai



Source: CSE analysis of real time data from CPCB website

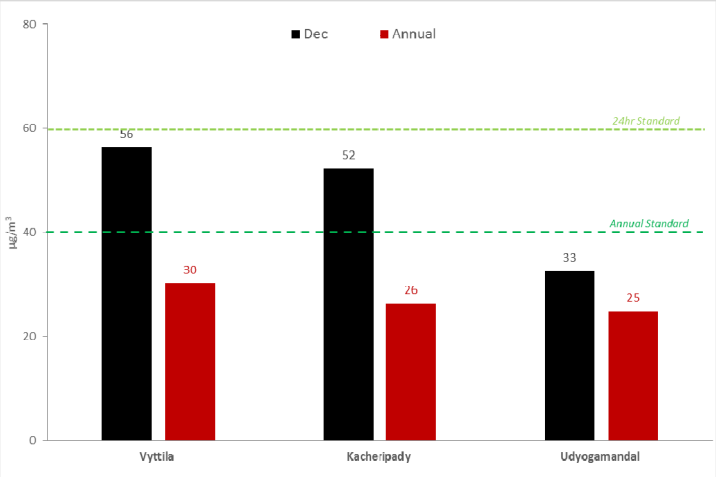
Kochi: Analysis of days as per AQI categorisation shows that Kochi city has not been able to sustain the air quality gains of 2020. Number of days when the AQI was worse than satisfactory level was 8 in 2021, - up by 4 days in 2020. But 2019 had witnessed 50 days above the satisfactory category (See Graph 15: PM2.5 AQI trend in Kochi). Most significant reduction is noted among "good" AQI days which are down by 43. Within the city Vyttila has the worst air with its December average adding up to 56 ug/m3. Udyogamandal has least polluted air with 33 ug/m3 monthly average for December (See Graph 16: Variation in PM2.5 level among city stations of Kochi).

Graph 15: PM2.5 AQI trend in Kochi



Note: PM2.5 values is based on average of all stations that have continuous and adequate data for complete assessment period. Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

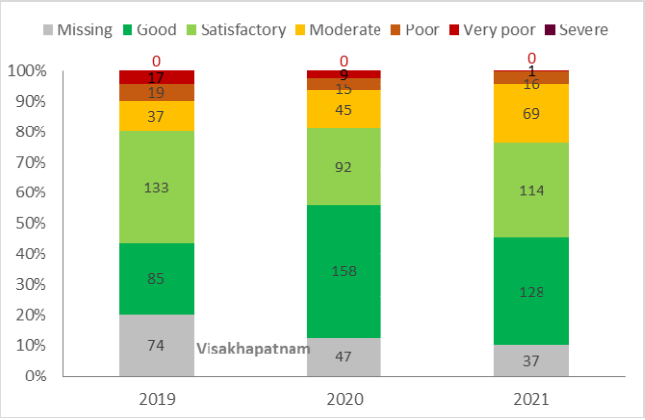
Graph 16: Variation in PM2.5 level among city stations of Kochi



Source: CSE analysis of real time data from CPCB website

Visakhapatnam: Analysis of days as per AQI categorisation shows that Visakhapatnam city has not been able to sustain air quality gains of 2020. Number of days when the AQI was worse than satisfactory has risen to 86 days in 2021, in contrast to 69 days in 2020 and 73 days in 2019 (See Graph 17: PM2.5 AQI trend in Visakhapatnam). Though number of days with very poor AQI has come down but this overall increase in bad air days is alarming.

Graph 17: PM2.5 AQI trend in Visakhapatnam



Note: Data up till 31 December 2021.
Source: CSE analysis of real time data from CPCB website

Next steps

States in southern India have unique locational advantage with sea and well ventilated atmosphere and more moderate climate that prevents pollution build up during winter like it happens in North India. But this region is at the risk of losing the air quality gains of pandemic though it has not yet reached the pre-pandemic levels. However, doubling of pollution during winter also indicates high local pollution and exposure that normally is not well captured in the annual average trends. This indicates the need for urgent action across all sectors to control pollution from vehicles, industry, power plants, waste burning, construction, and solid fuel use in households in all the states to meet the clean air standards throughout the year.