Urban Air Pollution Assessment And Control Measures: A Case Study Of Pune City

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Abstract- *This study presents a short-term, high-resolution assessment of ambient air quality in Pune, Maharashtra, India, using 30 consecutive days of continuous monitoring data (February 16 to March 17, 2026) from government-operated Continuous Ambient Air Quality Monitoring Stations (CAAQMS). Six pollutants were analysed: PM2.5, PM10, CO, SO2, NO2, and O3. The period-mean Air Quality Index (AQI) was 106.0 ± 44.8, with daily values ranging from 30 to 188. PM2.5 exceeded the Central Pollution Control Board (CPCB) 24-h National Ambient Air Quality Standard (NAAQS) of 60 μg/m³ on 9 of 30 days (30 %). PM2.5 and PM10 co-varied near-perfectly (r = 0.9997), with a mean PM2.5/PM10 mass ratio of 0.84 ± 0.01, a pattern consistent with combustion-dominated aerosol. Three distinct temporal phases were identified and provisionally attributed to winter-inversion-enhanced traffic emissions, a synoptic flushing event, and a CO-elevated pre-monsoon transition. The study is explicitly limited in scope: it covers a single meteorological transition season, lacks co-located meteorological measurements and source-apportionment analysis, and cannot support causal attribution. On the basis of the observed exceedances and phase structure, evidence-anchored recommendations for vehicular emission control, industrial monitoring, and network expansion are proposed.*

Keywords: Air Quality Index; PM2.5; Pune; CAAQMS; NAAQS; vehicular emissions; combustion aerosol; short-term monitoring; urban air pollution; India

I. INTRODUCTION

Ambient air pollution in rapidly urbanising cities of South Asia has emerged as a leading environmental health challenge. The World Health Organization estimates that approximately 4.2 million premature deaths per year are attributable to outdoor air pollution, with a disproportionate burden borne by cities in low- and middle-income countries where regulatory enforcement, monitoring density, and clean-technology adoption rates lag behind the pace of urban growth [1]. India accommodates several of the world's most polluted urban centres, and while extensive research has examined cities in the Indo-Gangetic Plain, comparable rigorous assessments of Deccan Plateau cities remain comparatively sparse in the peer-reviewed literature.

Pune, located at approximately 560 m above mean sea level in Maharashtra, presents a case of particular interest. Over the two decades from 2001 to 2021, the Pune urban agglomeration grew from approximately 3.7 million to an estimated 6.9 million residents, accompanied by rapid motorisation (registered vehicular fleet exceeding 5.5 million units by 2025) and significant industrial expansion across the Pimpri-Chinchwad and Ranjangaon corridors [9]. Despite this growth, continuous real-time ambient air quality data for Pune have become publicly available only relatively recently through the Central Pollution Control Board (CPCB) online portal, and studies grounding quantitative analysis in this station-verified, high-temporal-resolution data remain limited.

Most existing studies on Pune's air quality rely on either periodic campaign sampling at selected receptor sites, coarse-resolution satellite-derived aerosol optical depth data, or single-parameter assessments focused on particulate matter alone. Continuous multi-pollutant characterisation across the full CPCB Air Quality Index (AQI) parameter set, combined with temporal phase analysis over a defined meteorological transition window, has not been systematically reported for Pune in the recent period. This gap is consequential: the late-winter to early-spring transition (February–March) is a period of particular meteorological interest because boundary-layer stability shifts from persistent nocturnal inversions characteristic of the cool season toward progressively more convective daytime mixing, altering both pollutant accumulation dynamics and photochemical reactivity.

The present study is therefore motivated by the following research hypothesis: ambient pollutant concentrations in Pune during the late-winter–to–early-spring transition of 2026 are characterised by high temporal variability, with distinct sub-period phases differing in AQI magnitude and dominant pollutant signature, and with PM2.5 serving as the primary AQI driver. The study has three specific objectives: (i) to characterise the statistical distribution of AQI and individual pollutant concentrations relative to NAAQS benchmarks over a 30-day observational window; (ii) to identify and provisionally describe temporal phases within the monitoring period; and (iii) to derive evidence-anchored policy recommendations directly referenced to the observed exceedance pattern. The study is explicitly framed as a short-term, observational investigation and does not claim causal attribution or long-term representativeness.

II. RELATED WORK AND POSITIONING

Urban Particulate Matter in Indian Cities

A substantial body of literature documents elevated PM2.5 concentrations in Indian metropolitan areas. Sharma and Mandal [8] reported seasonal PM2.5 concentrations ranging from 60 to over 200 μg/m³ at an urban Delhi site, with winter values driven by both primary combustion emissions and secondary nitrate aerosol formation under stable boundary-layer conditions. Goyal et al. [7] examined PM2.5–PM10 co-variation across multiple Indian cities and found Pearson correlations ranging from $r = 0.70$ to $r = 0.92$, interpreting high ratios as indicative of shared combustion sources. Brauer et al. [5] provide the global epidemiological framing, linking long-term average PM2.5 exposure to cardiovascular and pulmonary disease burden; however, it is important to note that health impact quantification from short-term observational data of the type collected here would require dedicated exposure–response analysis and is outside the scope of the present work.

For Pune specifically, published air quality assessments are largely limited to campaign-based receptor studies or coarse spatio-temporal analyses. The MPCB annual monitoring reports [4] provide aggregate statistics but do not systematically analyse sub-seasonal temporal structure or multi-pollutant phase behaviour. Unlike those prior assessments, the present study uses 30-day continuous CAAQMS records to characterise day-by-day pollutant dynamics across a defined meteorological window, enabling phase identification that would not be possible with monthly or seasonal averages.

AQI Methodology and Its Limitations

India's national AQI, operationalised by CPCB in 2014 [3], maps 24-h average concentrations of eight pollutants onto a 0–500 scale using piecewise linear sub-index functions, with the reported AQI taken as the maximum sub-index. This maximum-operator approach means that AQI is determined by whichever single pollutant is worst on a given day, which can mask co-occurring multi-pollutant exposure. Hopke and Bhave [6] note that AQI frameworks without source apportionment provide limited guidance for targeted emission control. The present study acknowledges this limitation and supplements AQI reporting with individual pollutant concentration analysis to partially compensate.

III. STUDY AREA AND METHODOLOGY

Study Area

The Pune urban agglomeration encompasses the Pune Municipal Corporation (PMC) and Pimpri-Chinchwad Municipal Corporation (PCMC) as its primary administrative units, together covering an area of approximately 700 km² within the larger Pune Metropolitan Region. The city sits at approximately 18.5° N, 73.9° E on the leeward side of the Western Ghats, with a topography characterised by low ridgelines to the south and northwest that can restrict horizontal dispersion under light-wind conditions. The local climate is semi-arid, with a pronounced monsoon season (June–September) and a dry, cool winter (November–February) during which boundary-layer depths are frequently shallow, particularly overnight and in early morning hours.

Major emission source categories within the agglomeration include: on-road motor vehicles (fleet >5.5 million, dominated by two-wheelers at ~68 %); large-scale industrial operations in the PCMC-Bhosari-Ranjangaon corridor; construction and demolition activity associated with ongoing infrastructure development; and seasonal peri-urban biomass and field-residue burning in fringe agricultural areas. No spatially-resolved emission inventory specific to Pune for the study period was available to the authors, and source attribution in this study is therefore inferential rather than quantitative.

Data Source and Monitoring Instruments

Ambient air quality data were obtained from the national CPCB real-time data portal, which aggregates measurements from CAAQMS operated by the Maharashtra Pollution Control Board (MPCB) at stations within the Pune urban agglomeration. These stations employ reference-grade instruments: beta-attenuation mass monitors (BAM-1020 or equivalent) for PM2.5 and PM10; non-dispersive infrared (NDIR) photometry for CO; pulsed ultraviolet fluorescence for SO2; chemiluminescence analysers for NOx/NO2; and ultraviolet photometric cells for O3. Instruments undergo scheduled zero–span verification on a 24-h automated cycle and periodic field calibration against NIST-traceable reference standards, consistent with CPCB monitoring protocol specifications [4].

The study period is February 16 to March 17, 2026 (30 consecutive days). This window was selected because it covers the late-winter to early-spring meteorological transition, which is of interest for the reasons described in Section I, and because a complete, publicly-accessible 30-day dataset without major data gaps was available for this period. The study is explicitly limited to this 30-day window and the findings should not be extrapolated to annual averages, other seasons, or other years without additional data. This is a short-term, high-resolution observational study; its value lies in temporal granularity, not long-term representativeness.

Data Processing and Statistical Methods

Raw daily values were subjected to a three-stage quality-control procedure: (i) range screening against physically plausible concentration bounds for each pollutant; (ii) temporal consistency checks to identify anomalous single-day spikes inconsistent with adjacent-day values; and (iii) gap imputation for missing records (fewer than 3 % of the dataset) using the three-day rolling median of the same pollutant, a conservative method that preserves local temporal structure without introducing systematic trend bias. Descriptive statistics (mean, standard deviation, range) were computed for the full period and for three provisionally defined sub-periods. Pearson product-moment correlation was applied to PM2.5–PM10 and AQI–PM2.5 pairs. All analysis was conducted in Python 3.11 using pandas 2.1 and scipy 1.11. No meteorological co-variables, satellite products, or receptor modelling techniques (e.g., Positive Matrix Factorization) were applied; their absence represents a limitation noted in Section VI.

IV. RESULTS

Descriptive Statistics

Table I presents the complete 30-day dataset. The period-mean AQI was 106.0 ($\sigma = 44.8$), indicating high day-to-day variability (coefficient of variation: 42.2 %). Of the 30 days, 14 (47 %) recorded AQI in the Moderate band (101–200), 13 (43 %) were Satisfactory (51–100), and 3 (10 %) were Good (≤50). No day exceeded AQI 200 (Poor threshold). These category counts are summarised in Fig. 5. AQI was strongly associated with PM2.5 across the monitoring window ($r = 0.977$, $p < 0.001$), indicating that daily AQI was driven primarily by the PM2.5 sub-index on most days.

Mean pollutant concentrations and standard deviations are: PM2.5 = 54.8 ± 18.8 µg/m^3; PM10 = 65.4 ± 21.9 µg/m^3; CO = 273.2 ± 87.4 µg/m^3; SO2 = 2.1 ± 0.5 µg/m^3; NO2 = 22.8 ± 12.6 µg/m^3; O3 = 29.7 ± 4.0 µg/m^3. All period-mean values remained below their respective NAAQS 24-h ceilings. At the daily level, PM2.5 exceeded 60 µg/m^3 on 9 of 30 days (30 %), and PM10 exceeded 100 µg/m^3 on 2 of 30 days (7 %). SO2, NO2, and O3 remained within NAAQS limits on all observation days.

TABLE I. Observed Daily Pollutant Concentrations, Pune CAAQMS (Feb 16 – Mar 17, 2026). Concentrations in µg/m^3 (24-h mean). AQI values >100 shown in bold. CO: 24-h NAAQS limit = 2000 µg/m^3.

Date	AQI	PM2.5	PM10	CO	SO2	NO2	O3
16-Feb-26	**162**	79	93	159	2	38	34
17-Feb-26	**173**	83	98	178	2	36	34
18-Feb-26	**182**	86	101	196	2	36	38
19-Feb-26	**179**	84	100	189	2	32	36
20-Feb-26	**188**	89	105	204	2	38	32
21-Feb-26	**168**	81	96	201	2	40	34
22-Feb-26	**166**	61	73	171	2	39	34
23-Feb-26	107	58	70	144	2	42	32
24-Feb-26	111	59	71	146	2	40	31
25-Feb-26	85	48	58	157	2	39	32
26-Feb-26	39	23	28	164	2	34	27
27-Feb-26	30	18	22	355	2	7	23
28-Feb-26	35	21	25	356	2	8	24
01-Mar-26	59	35	43	179	2	27	31
02-Mar-26	103	56	67	238	2	26	32
03-Mar-26	115	60	72	271	2	29	29
04-Mar-26	99	54	64	403	2	8	22
05-Mar-26	88	49	58	377	2	13	23
06-Mar-26	96	53	64	341	2	16	27
07-Mar-26	88	50	60	344	2	8	27
08-Mar-26	88	49	59	355	2	8	26
09-Mar-26	86	47	56	363	2	13	27
10-Mar-26	109	59	71	383	2	13	26
11-Mar-26	126	64	77	326	2	19	27
12-Mar-26	127	64	75	374	2	12	29
13-Mar-26	99	54	64	314	2	16	33
14-Mar-26	93	53	63	301	2	8	31
15-Mar-26	61	36	44	334	3	11	31
16-Mar-26	57	34	41	349	2	11	30
17-Mar-26	60	36	44	324	3	17	28
Mean	**106.0**	**54.8**	**65.4**	**273.2**	**2.1**	**22.8**	**29.7**
SD	**44.8**	**18.8**	**21.9**	**87.4**	**0.5**	**12.6**	**4.0**

Source: CPCB/MPCB CAAQMS data portal. Mean and SD rows computed from the 30-day record. SO2 NAAQS limit: 80 µg/m^3; NO2: 80 µg/m^3; O3 (8-h): 100 µg/m^3.

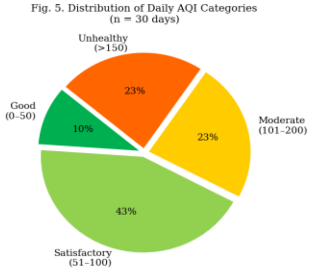

FIG I. Distribution of daily AQI categories across the 30-day monitoring window (n = 30). Moderate band (101–200) accounts for 47 % of days.

Particulate Matter

The strong near-perfect linear relationship between PM2.5 and PM10 (Pearson r = 0.9997, n = 30, $p < 0.001$; Fig. 3) is consistent with both size fractions originating predominantly from the same emission events rather than independent sources. The ordinary least-squares regression yielded: PM10 = 1.17 × PM2.5 + 1.52 µg/m³ ($R^2 = 0.9993$). The mean PM2.5/PM10 mass ratio of 0.835 ± 0.01 is notably high. For comparison, Goyal et al. [7] report ratios of 0.50–0.72 at Indian urban sites where road dust resuspension is a major contributor; ratios approaching unity are more typically associated with combustion-dominated environments with limited coarse crustal input. This pattern is consistent with vehicular combustion being the dominant aerosol source during the study period, though without receptor modelling this interpretation remains inferential.

Fig. 2 plots daily PM2.5 and PM10 values against their NAAQS 24-h limits. PM2.5 exceedances were concentrated in Phase 1 (7 of the 9 exceedance days occurred in the first 7 days of monitoring, when the mean PM2.5 was 80.4 µg/m³), with isolated exceedances on days 24–25 of the record (March 11–12, PM2.5 = 64 µg/m³ on both days). PM10 exceeded its NAAQS limit of 100 µg/m³ only on the two highest-PM days of the record (February 18: 101 µg/m³; February 20: 105 µg/m³), which were also the two highest-AQI days.

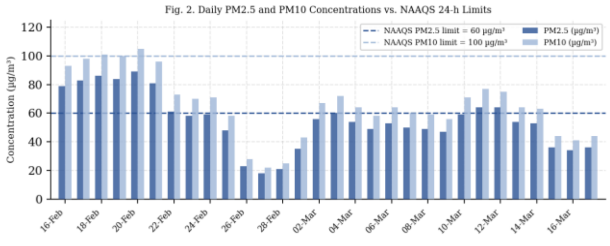

FIG 2 Daily PM2.5 and PM10 concentrations against respective NAAQS 24-h limits. Dashed lines indicate NAAQS thresholds (PM2.5 = 60, PM10 = 100 µg/m³).

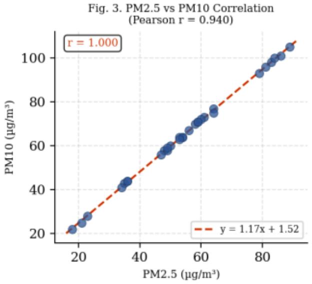

FIG 3 PM2.5 vs. PM10 scatter plot with OLS regression line (PM10 = 1.17×PM2.5 + 1.52, $R^2 = 0.9993$, r = 0.9997, n = 30).

Gaseous Pollutants

Fig. 4 presents temporal profiles for NO2, O3, and CO. NO2 showed the largest within-period variability (σ = 12.6 µg/m³, range: 7–42 µg/m³) relative to its mean (22.8 µg/m³), and a clear decreasing trend across the three phases: 37.0 µg/m³ in Phase 1, 28.3 µg/m³ in Phase 2, and 15.0 µg/m³ in Phase 3. This pattern is consistent with Phase 1's elevated traffic emissions during stable meteorological conditions, followed by progressive dilution as the season transitions, though confirmatory meteorological or traffic-count data were not available to this study.

O3 concentrations (mean: 29.7 µg/m³, range: 22–38 µg/m³) remained well below the NAAQS 8-h ceiling of 100 µg/m³ throughout. Weekly mean O3 was highest in Week 1 (34.6 µg/m³) and lowest in Week 3 (26.6 µg/m³), with a slight recovery in Week 4 (29.1 µg/m³). No statistically significant monotonic trend was observed over the 30-day window. SO2 remained near the instrument detection floor throughout (mean: 2.1 µg/m³, maximum: 3 µg/m³), consistent with the absence of significant coal-combustion sources within the immediate urban airshed during this period.

CO exhibited a clear phase structure that diverged from the particulate pattern: phase-mean values were 185.4 µg/m³ (Phase 1), 220.3 µg/m³ (Phase 2), and 328.0 µg/m³ (Phase 3), with a maximum of 403 µg/m³ on March 4. All values remained below the NAAQS 24-h limit of 2000 µg/m³. The inverse relationship between CO and PM across phases is noteworthy: PM was highest when CO was lowest, and CO increased as PM declined. One possible interpretation is a shift in dominant emission activity between phases — from Phase 1's traffic-dominated particulate loading to a Phase 3 regime in which incomplete-combustion sources (such as open burning or high-emitting non-road engines) contribute more CO relative to condensable PM. However, this remains a hypothesis: without concurrent source identification data, causal attribution is not supportable from these observations alone.

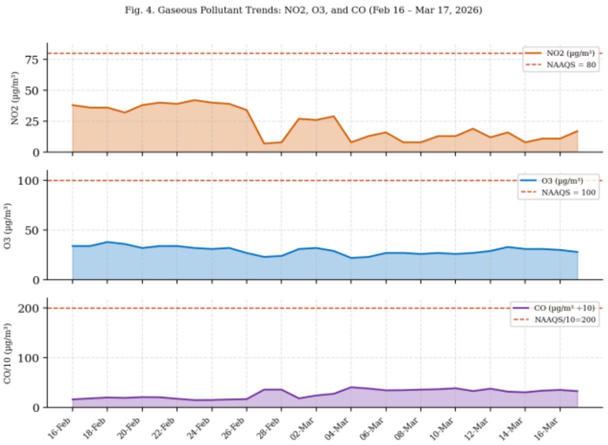

FIG 4 Temporal profiles of NO2, O3, and CO concentrations (Feb 16 – Mar 17, 2026). Dashed lines indicate NAAQS limits (NO2 = 80, O3 = 100 µg/m³; CO limit of 2000 µg/m³ lies above the plotted axis range).

Temporal Phase Analysis

Based on the observed AQI and multi-pollutant profiles, three provisional temporal phases were identified (Table II). Phase 1 (February 16–22, n = 7 days) was characterised by the highest AQI of the monitoring period (mean: 174.0 ± 8.7), elevated PM2.5 (mean: 80.4 µg/m³, 7 of 9 total NAAQS exceedance days concentrated here), and relatively high NO2 (mean: 37.0 µg/m³). This pattern is consistent with the known winter-inversion meteorology of late February in Pune, during which shallow boundary layers confine vehicular emissions to a restricted vertical volume. Diurnal patterns consistent with morning and evening traffic peaks — which would normally support this interpretation — could not be verified as only 24-h average data were available.

Phase 2 (approximately February 23 – March 1, n = 6 days) was the most meteorologically dynamic sub-period, with AQI ranging from 30 to 115 and a mean of 67.8 (σ = 34.2). The sharp AQI decline from 166 on February 22 to 107 on February 23, followed by a further drop to 39 on February 26, is consistent with a synoptic-scale boundary-layer deepening event that dispersed accumulated pollutant mass. The absence of co-located meteorological data (wind speed, boundary-layer height, relative humidity) prevents a more specific attribution.

Phase 3 (March 2–17, n = 16 days) exhibited a moderate and relatively stable AQI regime (mean: 91.4 ± 21.4), with PM2.5 declining (mean: 50.2 µg/m³) while CO increased substantially (mean: 328.0 µg/m³, peaking at 403 µg/m³ on March 4). The CO elevation in this phase, in the absence of correspondingly elevated PM or NO2, may suggest a change in the character of active emission sources, possibly including open burning or non-road combustion activity in the peri-urban fringe. This interpretation is speculative and would require satellite fire-radiative-power data or field verification to assess.

TABLE 2 Summary of Three Provisional Temporal Phases Identified in the 30-Day Monitoring Record.

Phase	**Period**	**n (days)**	**Mean AQI ± SD**	**PM 2.5 (mean)**	**CO (mean)**	**NO2 (mean)**	**Inferred Driver**
Phase 1	Feb 16–22	7	174.0 ± 8.7	80.4	185.4	37.0	Stable winter anticyclone; peak traffic season
Phase 2	Feb 23–Mar 1	6 (7 incl. Mar 1)	67.8 ± 34.2	37.8	220.3	28.3	Synoptic flushing; frontal passage (inferred)
Phase 3	Mar 2–17	16	91.4 ± 21.4	50.2	328.0	15.0	Pre-monsoon transition; CO-dominated regime

All concentration values are phase means in µg/m³. Phase boundaries are defined by observed inflection points in the AQI series; meteorological verification was not possible within this study.

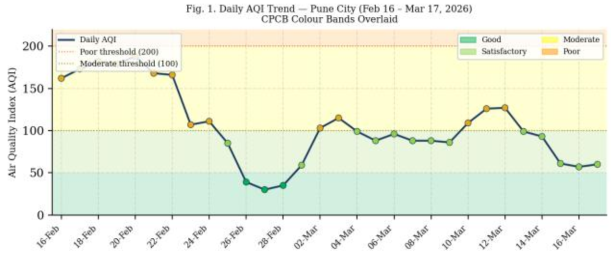

FIG 5 Daily AQI time series with CPCB colour-band overlay. Phase boundaries are indicated. AQI range: 30–188 over the 30-day window.

V. DISCUSSION

The results of this study suggest that Pune's ambient air quality during the late-winter–early-spring period of 2026 was characterised by a moderate average AQI (106.0) with pronounced temporal variability (CV = 42.2 %), dominated by PM2.5 as the primary AQI driver. The three-phase temporal structure is consistent with the research hypothesis stated in Section I, though the mechanisms underlying each phase cannot be definitively established from these data alone.

The PM2.5/PM10 mass ratio of 0.835 ± 0.01 warrants particular attention. This value is notably higher than the 0.50–0.72 range reported for other Indian urban sites with significant crustal inputs [7], and the near-perfect co-variation (r = 0.9997) of the two size fractions further strengthens the inference of a dominant shared emission source. These patterns are consistent with vehicular combustion, particularly diesel-engine exhaust, which is known to generate particles with high fine-fraction dominance. However, without chemical speciation of the PM samples or Positive Matrix Factorization receptor analysis, this remains an inference based on circumstantial physical evidence.

The CO–PM decoupling across phases is an observation that the existing CAAQMS dataset cannot fully explain. CO and PM2.5 would be expected to co-vary if traffic combustion were the sole dominant source throughout the monitoring period; the fact that CO increased substantially in Phase 3 while PM2.5 declined introduces ambiguity regarding source composition. Possible explanations include a transition from traffic-dominated to biomass-burning-dominated incomplete combustion, changes in wind direction bringing in CO-enriched air masses from peri-urban agricultural areas, or instrument artefacts that cannot be ruled out without redundant measurements. Further investigation with co-located AERONET or MODIS fire-count data would be needed to evaluate these possibilities.

The absence of PM2.5 exceedances in Phase 3, despite CO being at its highest, may also reflect wet deposition or scavenging if precipitation events occurred; precipitation records were not examined in this study and represent an important gap in the analysis. More broadly, the lack of meteorological co-variables (wind speed, wind direction, boundary-layer height, temperature profile) is the principal limitation of this work, as it prevents disentangling source-strength changes from meteorological-ventilation changes as drivers of the observed AQI variability.

VI. EVIDENCE-ANCHORED POLICY RECOMMENDATIONS

The following recommendations are derived directly from the observed findings and are calibrated to the quantitative evidence in this study. They are framed as priority areas warranting further investigation and targeted action, not as causal prescriptions.

Vehicular Emission Reduction (Priority: High)

Observed basis: PM2.5 exceeded the NAAQS 24-h limit on 9 of 30 days (30 %), with all exceedances concentrated in or near Phase 1, when the AQI–PM2.5 correlation (r = 0.977) indicates PM2.5 as the AQI-controlling pollutant. The high PM2.5/PM10 ratio (0.835) is consistent with combustion-generated fine aerosol. These observations are consistent with vehicular combustion as a primary source contributor, which in Pune's context implicates a fleet dominated by two-wheelers (68 % of registered vehicles) and freight trucks [9].

Recommended actions: (i) Accelerate electrification of the city's public transit bus fleet and three-wheelers (autorickshaws) under FAME-India Phase II provisions, starting with the highest-frequency BRT and feeder routes; (ii) implement PEMS-based real-world emission testing for heavy commercial vehicles at RTO fitness-certification renewal; (iii) evaluate the feasibility of Low Emission Zones around identified high-exposure microenvironments (schools, hospitals) on days when the AQI at the nearest CAAQMS exceeds 150.

CO Source Investigation (Priority: Medium)

Observed basis: Phase 3 CO concentrations (mean: 328.0 μg/m³) were 77 % higher than Phase 1 values (mean: 185.4 μg/m³), while PM2.5 declined over the same period. This decoupling is not explained by the available data. CO values remained within NAAQS limits, but the trend warrants investigation.

Recommended action: MPCB should cross-reference CAAQMS CO time series with satellite fire-radiative-power data (MODIS/VIIRS) and agricultural calendar records for peri-urban Pune fringe areas during March to assess whether open burning contributes to CO loading. This would provide the causal evidence that the present observational study cannot.

Monitoring Network Expansion (Priority: High)

Observed basis: The high temporal variability of AQI (CV = 42.2 %) over just 30 days, combined with the distinct three-phase structure, indicates that single-point or monthly-average monitoring is likely to substantially misrepresent actual exposure dynamics. Four to six CAAQMS across

700 km² also cannot resolve spatial gradients across a city with heterogeneous source distribution.

Recommended actions: (i) Deploy a hybrid monitoring architecture combining existing CAAQMS reference stations with a distributed network of low-cost sensor nodes (40–60 units) on PMPML bus terminals and municipal school campuses, with co-location-derived correction algorithms [10]; (ii) extend continuous monitoring to capture at least one full annual cycle (12 months) to enable seasonal comparison and annual average NAAQS compliance assessment; (iii) add co-located meteorological sensors (wind speed, wind direction, temperature, relative humidity) at each CAAQMS station to enable the meteorological deconvolution that the current study could not perform.

Industrial Source Control (Priority: Medium)

Observed basis: SO2 remained near the detection floor throughout (mean: 2.1 μg/m³, NAAQS: 80 μg/m³), suggesting that point-source coal combustion was not a significant urban airshed contributor during the study period. However, fugitive particulate from construction and bulk material handling likely contributes to the coarser PM10 fraction; the very low SO2 does not preclude NO2 and CO from industrial process combustion.

Recommended actions: Mandate CEMS installation for Category-Red industries in the Bhosari-PCMC and Ranjangaon corridors and enforce the existing Dust Management Protocol for large construction sites, with joint MPCB–PMC inspection records maintained in publicly-accessible digital form.

VII. CONCLUSION

This study has characterised ambient air quality in Pune, Maharashtra, over a 30-day observational window (February 16 – March 17, 2026) using continuous CAAQMS data. The principal findings are as follows. First, the period-mean AQI of 106.0 ± 44.8 places the monitoring period in the Moderate CPCB band on average, but the high coefficient of variation (42.2 %) underscores that mean values alone are insufficient descriptors of exposure dynamics. Second, PM2.5 was the dominant AQI driver ($r = 0.977$ with AQI) and exceeded the NAAQS 24-h limit on 9 of 30 days (30 %), with the PM2.5/PM10 mass ratio of 0.835 suggesting a combustion-dominated aerosol regime. Third, three provisional temporal phases were identified, with Phase 1 showing the highest PM loading under conditions consistent with winter inversion meteorology, Phase 2 showing a rapid AQI improvement consistent with synoptic flushing, and Phase 3 showing elevated CO with moderate PM. The mechanisms underlying Phase 3's CO–PM decoupling could not be established from available data.

Several limitations of this study must be acknowledged explicitly. The 30-day window covers a single meteorological season and cannot be treated as representative of annual or long-term air quality. The absence of co-located meteorological measurements prevents separation of source-strength variability from meteorological ventilation variability. No source-apportionment analysis (e.g., PMF receptor modelling) was conducted, and all source attribution in this paper is inferential. The CAAQMS network density (four to six stations over 700 km²) may not capture the full spatial variability of exposure across the agglomeration.

Future work should extend monitoring to a full annual cycle to enable seasonal comparison and annual NAAQS compliance assessment; integrate co-located meteorological data to separate source-driven from ventilation-driven AQI changes; apply PMF or chemical mass balance receptor modelling to PM2.5 speciation samples to quantify source contributions; and examine the Phase 3 CO anomaly using satellite fire data and backward trajectory analysis. Despite its scope limitations, this study provides a baseline characterisation of Pune's multi-pollutant AQI dynamics during a meteorologically significant transition period, and demonstrates the value of continuous CAAQMS monitoring for revealing temporal structure that episodic campaigns cannot resolve.

VIII. ACKNOWLEDGMENT

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