
ADVANCING SUSTAINABLE URBAN MOBILITY: A TRAFFIC-RELATED AIR QUALITY ASSESSMENT AT MAJOR ROAD INTERSECTIONS IN KANO METROPOLIS, NIGERIA

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ABSTRACT

Urban air quality deterioration driven by vehicular traffic is a critical public health challenge in rapidly growing Nigerian cities. Road intersections represent pollution hotspots where idling, acceleration, and deceleration generate elevated concentrations of harmful pollutants. This study assesses air quality at four major intersections in Kano metropolis by evaluating spatial-temporal pollutant variations and compliance with World Health Organization (WHO) and Nigerian Ambient Air Quality Standards (NAQS). Field measurements were conducted for eight weeks at the intersections; NNPC Mega (P1), Kwanar Sabo (P2), Aliko by Maiduguri Road (P3), and Gadar Lado (P4) intersections, with Hoto GRA serving as a control site (P5). Concentrations of $PM_{1.0}$, $PM_{2.5}$, PM_{10} , CO, NO₂, SO₂, and total volatile organic compounds (TVOCs) were measured twice weekly on Sundays and Mondays during morning, afternoon, and evening periods using a multi-gas detector and air quality monitor. All four sites recorded pollutant concentrations significantly higher than the control site (intersection-to-control ratios: 3.5 – 8.6×; Welch's t-test, $p < 0.001$ for all pollutants). $PM_{2.5}$ was the dominant pollutant, exceeding WHO guidelines (15 $\mu g/m^3$) by up to 13.9-fold on weekdays. At all four intersections, SO₂ exceeded the NAQS limit (0.048 ppm) on both measurement days, and NO₂ exceeded the NAQS limit (0.064 ppm) at three of the four intersections on Mondays. Weekday concentrations were 49 – 95% higher than weekend values across all parameters. Evening periods consistently produced the highest pollution levels. The signalized 4-way intersection (P2) recorded the highest overall pollution, while the T-junction (P3) recorded the lowest values, suggesting intersection geometry substantially influences pollutant dispersion. Air quality at major intersections in Kano metropolis frequently falls within moderate to severe pollution categories, posing substantial health risks to commuters, pedestrians, and roadside workers. Urgent implementation of intelligent traffic management, vehicle emission controls, and continuous monitoring systems is recommended.

Keywords: Air quality assessment; traffic-related air pollution; road intersections; particulate matter; Kano metropolis; WHO; NAQS

1. INTRODUCTION

Urban air quality has become a defining environmental and public health challenge in rapidly growing developing-world cities, where vehicular expansion frequently outpaces regulatory and infrastructural capacity (Emereibe et al., 2023). Road traffic is a principal source of pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO₂), total volatile organic compounds (TVOCs) and particulate matter (PM), all of which are associated with adverse respiratory and cardiovascular outcomes (Chen et al., 2022; Amegah & Agyei-Mensah, 2017).

Road intersections are especially critical microenvironments within the urban transport network. Unlike free-flowing sections of road, intersections concentrate vehicle idling, deceleration and acceleration events tied to traffic signal phases, queue formation and geometric constraints, producing localized emission "hotspots" that can differ markedly from ambient background levels (Šarić et al., 2023; Hailu et al., 2024). Emission rates during acceleration and idling are disproportionately higher than during steady cruising, so the exposure experienced by commuters, traders and traffic personnel at junctions can be substantially elevated relative to general roadside conditions.

Kano, northwestern Nigeria's largest commercial hub with a population exceeding four million, exhibits many of the classic conditions associated with severe intersection pollution: high vehicular density, mixed heavy- and light-duty fleets, largely unsignalized or under-optimized junction control,

and a harmattan-dominated dry season that elevates background particulate loads through Saharan dust intrusion (Akinlade et al., 2020). Despite this, empirical, intersection-scale air quality data for Kano remain scarce compared with cities such as Lagos, Port Harcourt, Owerri and Warri, where similar assessments have been conducted (Nwankwo & Bamidele, 2025; Emereibeole et al., 2023). For context, the Ogbomoso study reported a wet-season particulate matter mean of 27.7 $\mu\text{g}/\text{m}^3$, with spikes up to 70.15 $\mu\text{g}/\text{m}^3$ at unpaved road intersections, attributed to heavy vehicular traffic, charcoal burning and seasonal harmattan dust (Nwankwo & Bamidele, 2025). In Owerri, particulate matter ranged from 8-27 $\mu\text{g}/\text{m}^3$ at strategic intersections but reached 400-500 $\mu\text{g}/\text{m}^3$ near open-air markets, while a co-monitored gaseous pollutant reached 0.055-0.089 ppm (approximately 100-160 $\mu\text{g}/\text{m}^3$) at busy junctions, linked to peak-hour congestion and market waste dumpsites (Emereibeole et al., 2023). In Warri, an annual baseline particulate matter mean of 36.38 $\mu\text{g}/\text{m}^3$ was recorded around petrochemical refinery buffer zones, with spikes exceeding 133 $\mu\text{g}/\text{m}^3$ near major transport corridors and a co-monitored gaseous pollutant averaging 0.0063 ppm, reflecting industrial and heavy diesel-traffic emissions. These comparator values are broadly consistent with the intersection-level concentrations reported for Kano in the present study (Table 3), though direct comparison is limited by differences in monitoring season, averaging period and instrumentation across studies.

This study addresses that gap by systematically measuring $\text{PM}_{1.0}$, $\text{PM}_{2.5}$, PM_{10} , CO, NO_2 , SO_2 and TVOC concentrations, together with temperature, relative humidity and the Air Quality Index (AQI), at four strategically selected road intersections and one residential control site in Tarauni Local Government Area, Kano State. The specific objectives are to (i) quantify and compare pollutant concentrations across intersections of differing geometry and traffic control; (ii) evaluate compliance with WHO and NAQS air quality guidelines; (iii) characterize temporal variation between weekday and weekend conditions and across morning, afternoon and evening peak periods; and (iv) draw evidence-based recommendations for traffic management and public health protection.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at four major road intersections and one residential control site within Kano metropolis, along the city's principal arterial corridors: Maiduguri Road (A3, the international corridor linking Kano to Borno, Yobe, Chad and Niger) and Zaria Road (A2, the national corridor linking Kano to Kaduna, Abuja and southwestern Nigeria). Sampling was carried out during the peak harmattan season (mid-December 2025 to mid-February 2026), characterized by Saharan dust intrusion (background PM_{10} frequently exceeding 100 $\mu\text{g}/\text{m}^3$), low relative humidity (<20%) and a wide diurnal temperature range (15-35 °C). Four intersections and one control site were selected using stratified purposive sampling to capture a representative range of traffic-control regimes and geometric configurations, as summarized in Table 1.

Table 1: Classification of sampling stations

Code	Station	Traffic control	Geometry	Corridor
P1	NNPC Mega Intersection	Unsignalized	4-way cross	Maiduguri Rd (A3)
P2	Kwanar Sabo Intersection	Signalized	4-way cross	Secondary arterial
P3	Aliko Maiduguri Rd Intersection	Signalized	3-way T-junction	Maiduguri Rd (A3)
P4	Gadar Lado Intersection	Unsignalized	4-way cross	A2 / A3
P5	Hotoro GRA (Control)	None (residential)	N/A	Estate roads

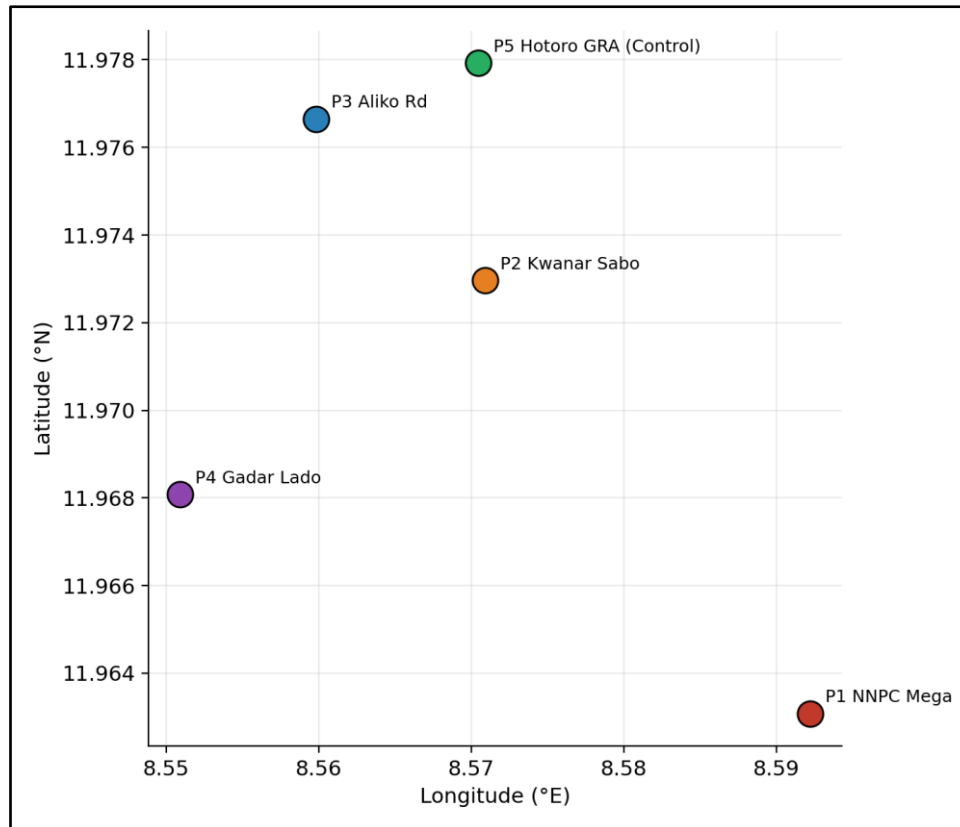


Figure 1: Spatial distribution of the five sampling stations in Tarauni LGA, Kano State

P1 (NNPC Mega) and P4 (Gadar Lado) are unsignalized four-way crossings characterized by high-speed, multi-directional approaches and a heavy proportion of inter-city trucks and articulated vehicles (35-45%). P2 (Kwanar Sabo) is a signalized four-way junction bounded by a partial street-canyon (motorcycle garage and buildings), which restricts pollutant dispersion. P3 (Aliko) is a signalized three-way T-junction with more open geometry. P5 (Hotoro GRA) is a low-density residential estate with negligible through-traffic (<50 vehicles/hour) and no signalized junction, serving as the non-intersection urban baseline.

2.2 Data Collection

Measurements were taken twice weekly - once on a working day (Monday) and once on a weekend day (Sunday) - over eight consecutive weeks, during three daily periods: morning peak (7:30-9:00 AM), midday off-peak (12:00-1:30 PM) and evening peak (4:30-6:00 PM). All readings were taken at 1.5 m height, corresponding to the breathing zone of drivers, pedestrians and traffic personnel.

Gaseous pollutants (CO, NO₂, SO₂) were measured using a calibrated Bosean BH-4S 4-in-1 portable multi-gas detector (Henan Borean Electronic Technology Co., Ltd., China), configured with electrochemical sensor channels for CO (0-1000 ppm range, 1 ppm resolution), NO₂ (0-20 ppm range, 0.1 ppm resolution) and SO₂ (0-20 ppm range, 0.1 ppm resolution); manufacturer-stated accuracy $\leq \pm 5\%$ F.S., response time ≤ 30 s, natural-diffusion sampling, and factory calibration with a 2-year rated sensor life. TVOC, together with particulate matter (PM_{1.0}, PM_{2.5}, PM₁₀), temperature, relative humidity and AQI were measured using a portable laser-scattering air quality monitor. At each visit, instruments were allowed to stabilize before recording; GPS coordinates were used to ensure identical sampling positions were revisited across the study period.

2.3 Standards and Data Analysis

Measured concentrations were compared against the WHO Global Air Quality Guidelines (2021) and the Nigerian Ambient Air Quality Standards (NAQS) under the National Environmental (Air Quality Control) Regulations (NESREA, 2014), summarized in Table 2. Descriptive statistics

(station means, weekday/weekend means, diurnal means) were computed from 207 valid station-period observations collected across the eight-week campaign, and pollutant exceedance ratios were calculated as the ratio of station mean concentration to the corresponding WHO guideline value. Standard deviations are reported alongside station means in Table 3. To test for differences in pollutant concentrations, one-way analysis of variance (ANOVA) was used to compare mean concentrations among the five stations for each pollutant, and Welch's independent-samples t-tests (unequal variances assumed) were used to compare weekday (Monday) versus weekend (Sunday) concentrations and intersection (P1-P4, pooled) versus control (P5) concentrations. All tests were evaluated at $\alpha = 0.05$ using the full station-period dataset (n up to 240 station-period-pollutant records per parameter, varying slightly by pollutant owing to isolated missing readings).

Table 2: WHO and NAQS air quality standards used for compliance assessment

Pollutant	WHO Guideline	NAQS Standard	Averaging period
PM _{2.5}	15 µg/m ³	35 µg/m ³	24-hour
PM ₁₀	45 µg/m ³	150 µg/m ³	24-hour
NO ₂	0.013 ppm	0.064 ppm	24-hour
SO ₂	0.015 ppm	0.048 ppm	24-hour
CO	4 mg/m ³	10 mg/m ³	8-hour

3. RESULTS AND DISCUSSION

A total of 207 valid station-period observations were recorded across the eight-week sampling campaign. Table 3 summarizes the overall mean pollutant concentrations by station.

Table 3: Overall mean $\pm$ standard deviation of pollutant concentrations by station (entire sampling period)

Station	PM _{2.5} (µg/m ³)	PM _{1.0} (µg/m ³)	PM ₁₀ (µg/m ³)	CO (mg/m ³)	NO ₂ (ppm)	SO ₂ (ppm)	TVOC (mg/m ³)
P1	130.8 $\pm$ 50.0	72.6 $\pm$ 27.2	142.0 $\pm$ 60.9	5.40 $\pm$ 3.15	0.081 $\pm$ 0.061	0.119 $\pm$ 0.067	0.58 $\pm$ 1.42
P2	148.7 $\pm$ 76.6	83.6 $\pm$ 40.6	148.7 $\pm$ 65.5	7.94 $\pm$ 5.86	0.121 $\pm$ 0.068	0.140 $\pm$ 0.061	2.65 $\pm$ 4.16
P3	91.6 $\pm$ 48.5	53.6 $\pm$ 25.9	98.5 $\pm$ 52.0	4.43 $\pm$ 4.13	0.049 $\pm$ 0.065	0.090 $\pm$ 0.068	0.48 $\pm$ 1.41
P4	109.3 $\pm$ 59.7	63.9 $\pm$ 32.5	122.6 $\pm$ 67.5	4.19 $\pm$ 3.92	0.091 $\pm$ 0.053	0.111 $\pm$ 0.077	0.31 $\pm$ 0.14
P5 (control)	30.0 $\pm$ 10.3	16.8 $\pm$ 6.7	33.1 $\pm$ 12.0	0.56 $\pm$ 0.86	0.006 $\pm$ 0.02	0.041 $\pm$ 0.048	0.02 $\pm$ 0.05

Across every pollutant, P5 (control) recorded the lowest concentrations by a wide margin, confirming its suitability as a non-intersection baseline. P2 (Kwanar Sabo) recorded the highest mean concentrations for nearly all parameters, consistent with its partial street-canyon geometry, signalized stop-and-go operation, and mixed commercial/motorcycle traffic. P3, the open T-junction, consistently recorded the lowest pollutant levels among the four intersections, suggesting that junction geometry - specifically the number of conflicting approaches and the degree of physical enclosure - exerts a measurable influence on local pollutant accumulation.

The station-to-station differences summarized in Table 3 were confirmed by one-way ANOVA, which found significant effects of station on mean concentration for every pollutant (PM_{2.5}: $F(4,235) = 34.5$, $p < 0.001$; PM_{1.0}: $F = 37.6$, $p < 0.001$; PM₁₀: $F = 32.6$, $p < 0.001$; CO: $F = 21.3$, $p < 0.001$; NO₂: $F = 29.7$, $p < 0.001$; SO₂: $F = 19.0$, $p < 0.001$; TVOC: $F = 12.2$, $p < 0.001$). Welch's t-tests further confirmed that concentrations at the four intersections (P1-P4, pooled) were significantly higher than at the control site (P5) for every pollutant (all $p < 0.001$, t-values ranging from 5.1 for TVOC to 19.4 for PM_{1.0}), and that weekday (Monday) concentrations were significantly higher than weekend (Sunday) concentrations for every pollutant ($p < 0.05$ for all seven parameters, $p < 0.001$ for PM_{2.5}, PM_{1.0}, PM₁₀ and SO₂). These results provide statistical support for the "significantly higher" language used elsewhere in this paper to describe intersection-to-control and weekday-to-weekend contrasts.

3.1 Particulate Matter (PM_{1.0}, PM_{2.5}, PM₁₀)

Particulate matter was the most critical pollutant class recorded in this study. Figure 2 compares overall mean PM_{1.0}, PM_{2.5} and PM₁₀ concentrations across the five stations against WHO and NAQS reference limits.

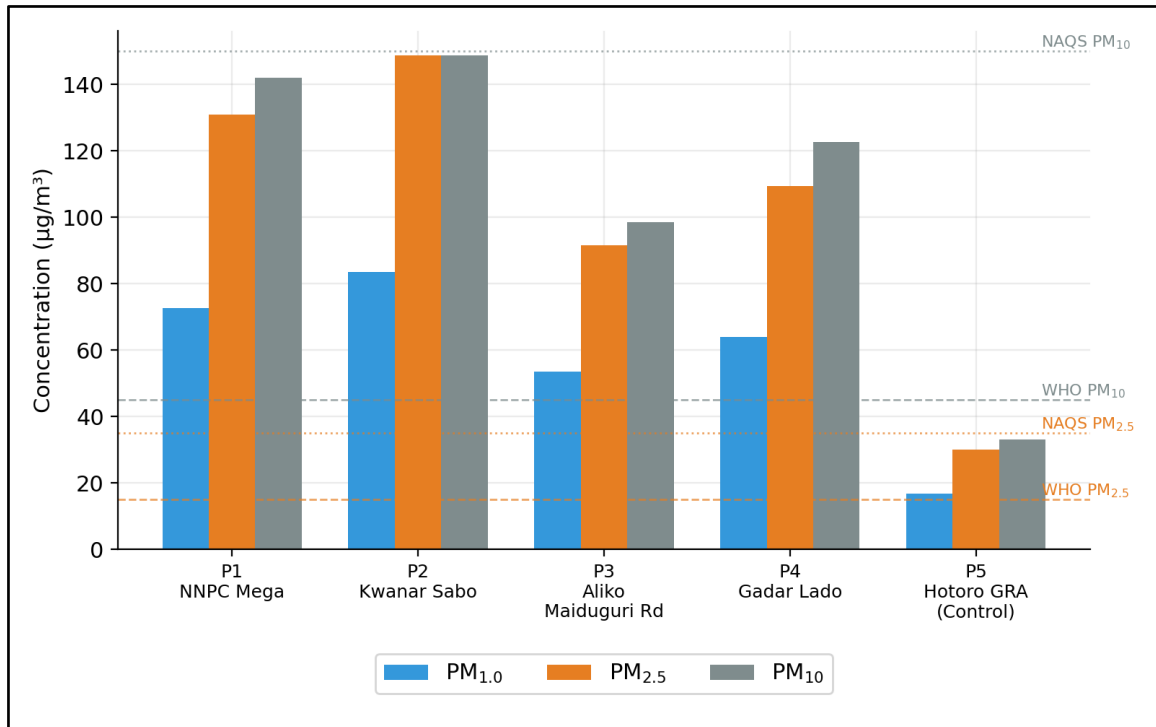


Figure 2: Overall mean particulate matter concentrations by station

Mean PM_{2.5} concentrations at the four intersections (91.6-148.7 µg/m³) exceeded the WHO 24-hour guideline (15 µg/m³) by factors of 6.1 to 9.9, and the NAQS limit (35 µg/m³) by factors of 2.6 to 4.2. Even the control site (30.0 µg/m³) exceeded the WHO guideline by a factor of 2.0, though it remained below the NAQS threshold, indicating a substantial regional background contribution from harmattan dust in addition to traffic-related emissions. PM₁₀ followed a similar pattern, with intersection means (98.5-148.7 µg/m³) consistently exceeding the WHO guideline (45 µg/m³) while remaining, on average, below the more permissive NAQS limit (150 µg/m³) except during isolated high-traffic episodes. Weekday-weekend contrasts were pronounced. Figure 3 and Figure 5 present station-level PM_{2.5} and PM₁₀ concentrations split by sampling day.

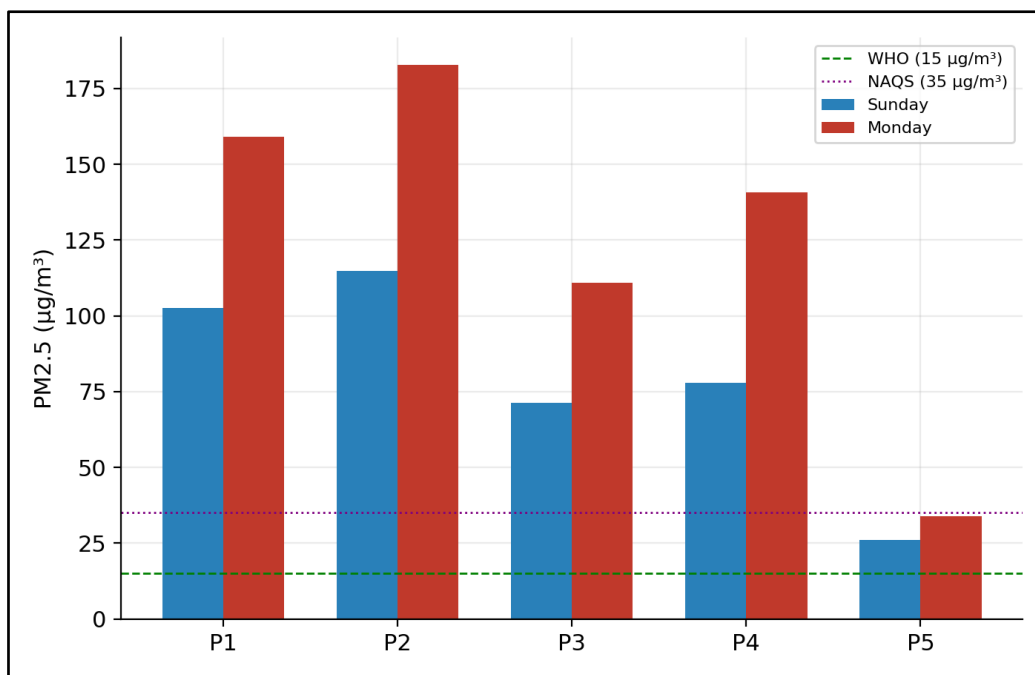


Figure 3: Weekend (Sunday) versus weekday (Monday) PM_{2.5} by station

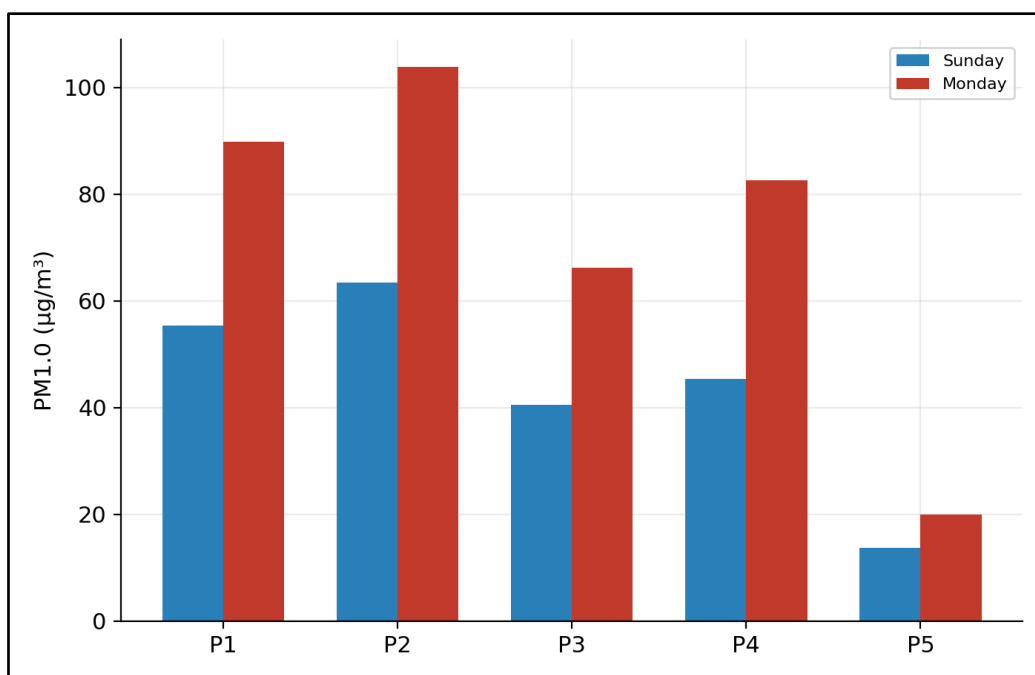


Figure 4: Weekend versus weekday PM_{1.0} (ultrafine particulate matter) by station

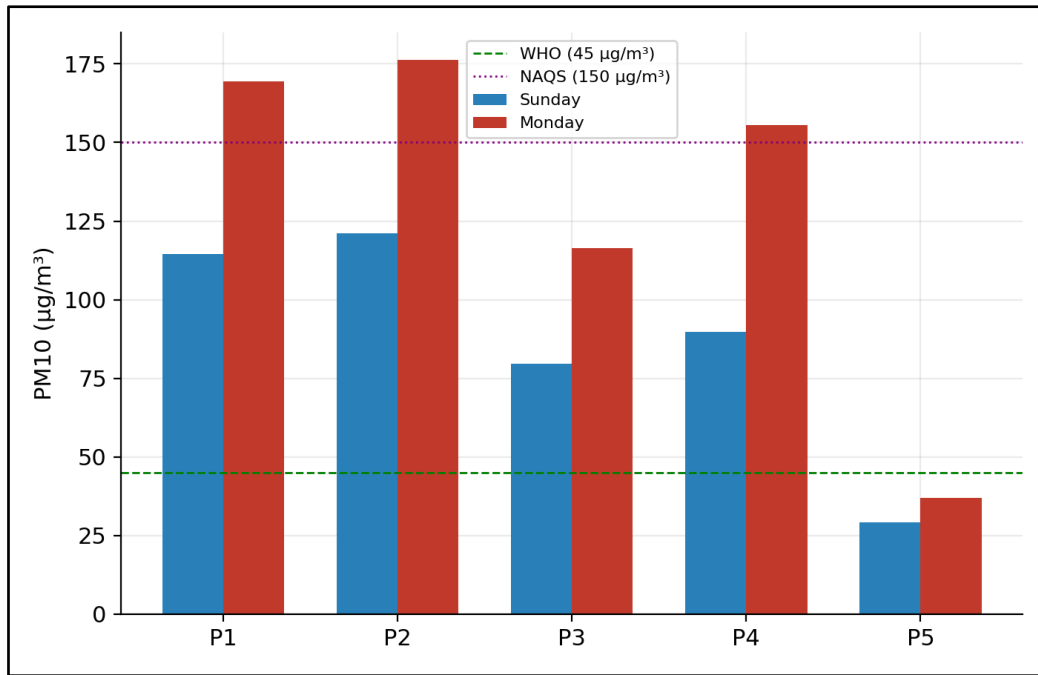


Figure 5: Weekend versus weekday PM₁₀ by station

PM_{2.5} concentrations on Mondays were 30-80% higher than on Sundays at all four intersections (e.g., P2: 114.7 µg/m³ on Sunday versus 182.7 µg/m³ on Monday), while the control site increased by a comparatively modest margin (26.1 to 33.9 µg/m³), confirming that the weekday excess is predominantly traffic-driven rather than purely meteorological. Ultrafine particulate matter (PM_{1.0}), attributable primarily to combustion aerosol from vehicle exhaust and diesel acceleration events, exhibited the same weekday elevation, with P2 rising from 63.4 µg/m³ (Sunday) to 103.8 µg/m³ (Monday).

Diurnal patterns (Figure 6) show a consistent rise from morning to evening across all stations, with evening peak-period concentrations 30-70% higher than morning concentrations. This pattern reflects the compounding effect of heavier evening traffic volumes, hotter engine operation, and the day's accumulated pollutant loading in the absence of strong atmospheric mixing during the harmattan season.

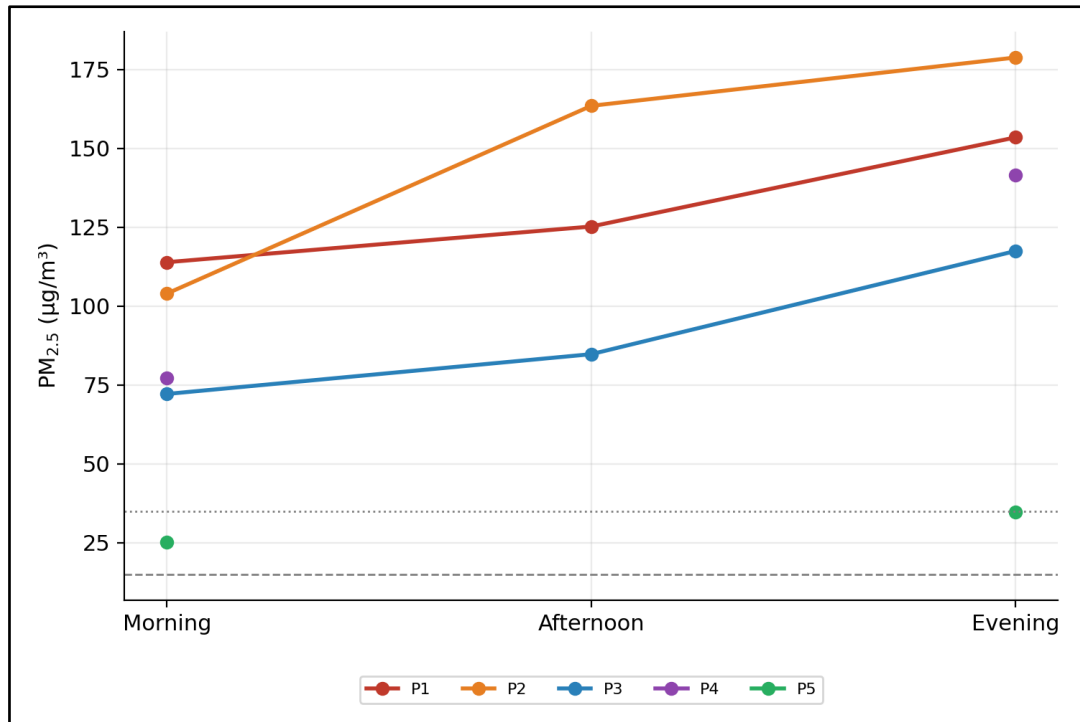


Figure 6: Diurnal variation of $PM_{2.5}$ across sampling stations

The eight-week temporal trend of mean $PM_{2.5}$ concentration (Figure 7) further shows that although week-to-week variability exists (attributable to fluctuating harmattan dust intensity and traffic volume), intersection stations remained persistently elevated above the control site throughout the entire monitoring period, with a marked spike in Week 8 across all stations, coincident with intensified regional dust loading toward the end of the harmattan season.

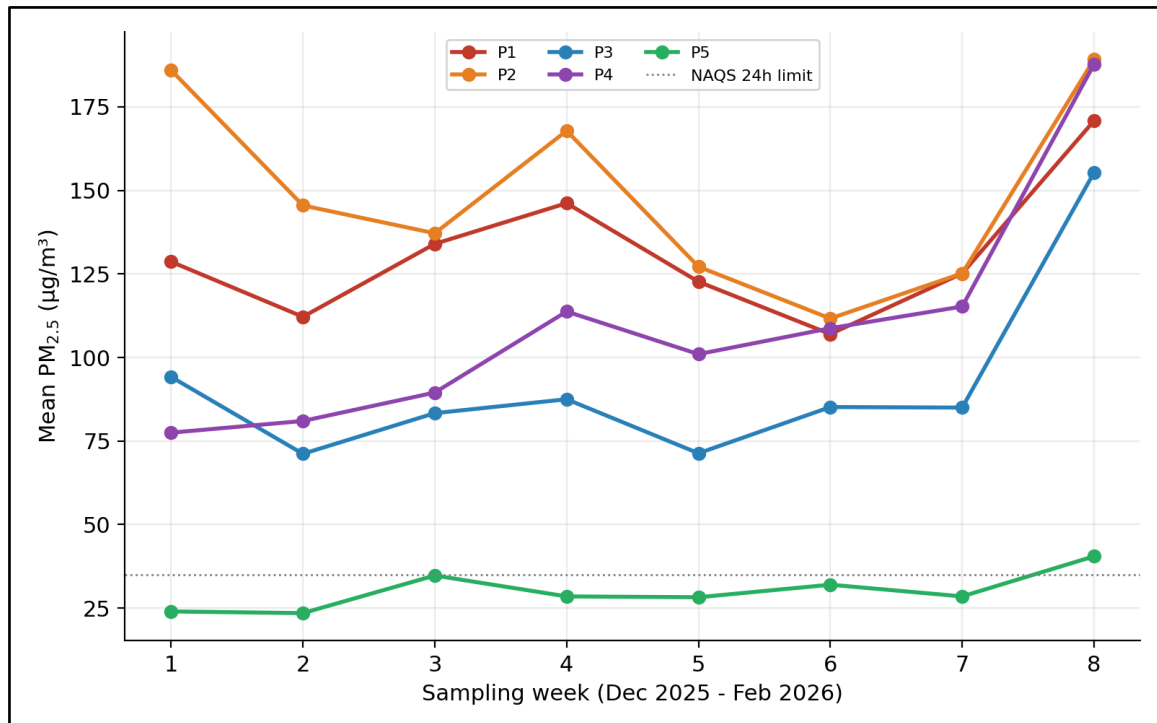


Figure 7: Eight-week temporal trend of mean $PM_{2.5}$ concentration by station

The pronounced weekday-weekend and diurnal contrasts observed across all pollutants - with Monday and evening-period concentrations consistently the highest - indicate that traffic volume and congestion state, rather than fixed emission sources, are the principal short-term determinants of

exposure at these locations. This has direct implications for exposure-reduction strategies, since even modest reductions in queuing and idling time at the most heavily trafficked junctions (P1 and P2) could yield disproportionate air quality benefits.

3.2 Gaseous Pollutants (CO, NO₂, SO₂)

Figure 8 presents overall mean CO, NO₂ and SO₂ concentrations by station relative to WHO and NAQS limits.

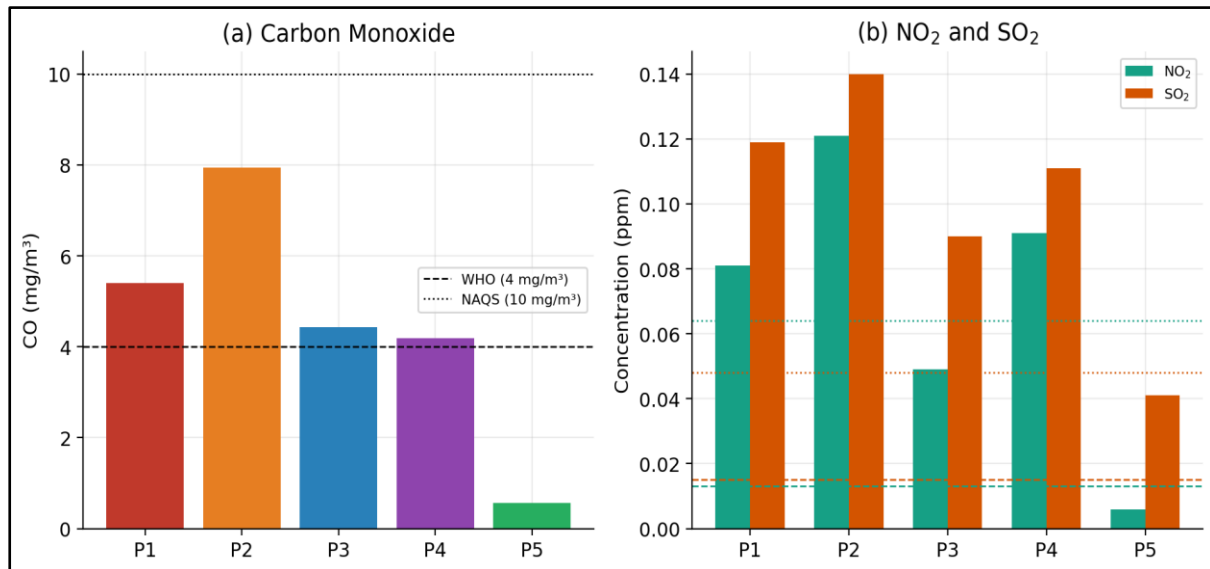


Figure 8: Overall mean gaseous pollutant concentrations by station

Mean CO concentrations at P1 (5.40 mg/m³) and P2 (7.94 mg/m³) exceeded the WHO guideline (4 mg/m³), while P3, P4 and P5 remained, on average, compliant. However, individual evening-period readings at P2 reached as high as 11.5 mg/m³ on Mondays, approaching the NAQS 8-hour limit (10 mg/m³) and reflecting severe idling combined with restricted dispersion from the partial street-canyon at that junction.

NO₂ and SO₂ concentrations were consistently elevated at all four intersections relative to WHO guidelines (0.013 ppm and 0.015 ppm respectively), by factors of up to 9.3x for NO₂ and 9.3x for SO₂ at P2 (0.121 ppm / 0.013 ppm $\approx$ 9.31 and 0.140 ppm / 0.015 ppm $\approx$ 9.33, respectively; the near-identical values are a numerical coincidence rather than a rounding artefact). Monday NO₂ concentrations at P2 (0.150 ppm) exceeded even the more permissive NAQS limit (0.064 ppm) by a factor of approximately 2.3, identifying this junction as the most critical NO₂ hotspot in the study. Notably, SO₂ at the control site rose to a mean of 0.041 ppm (and individual Monday values above 0.06 ppm), exceeding the WHO guideline even in the residential control area - evidence that SO₂ pollution in Kano is not confined to intersection microenvironments but reflects a broader urban emissions background, likely including generator use and fuel combustion beyond road traffic. Weekday-weekend and station-level comparisons for CO, NO₂ and SO₂ are presented in Figures 9-11.

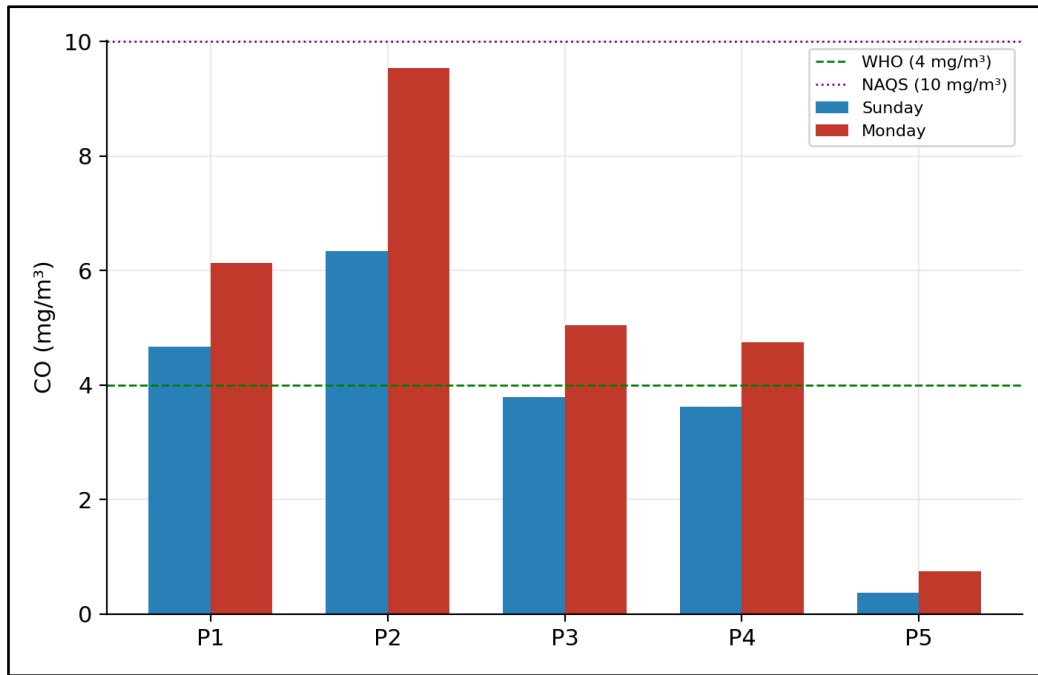


Figure 9: Weekend versus weekday Carbon Monoxide (CO) by station

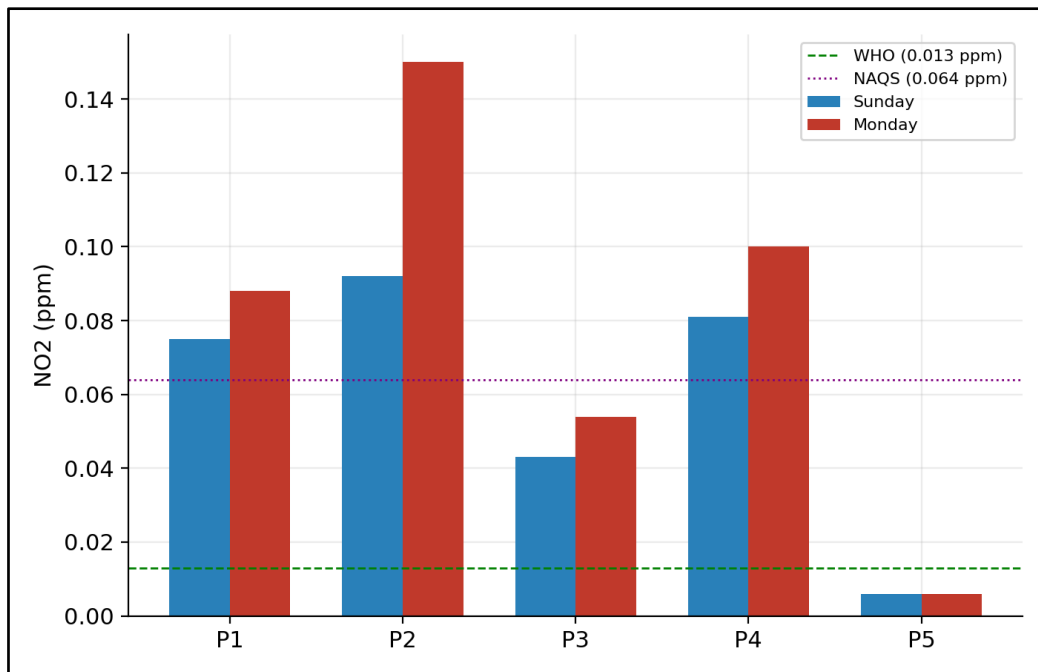


Figure 10: Weekend versus weekday Nitrogen Dioxide (NO₂) by station

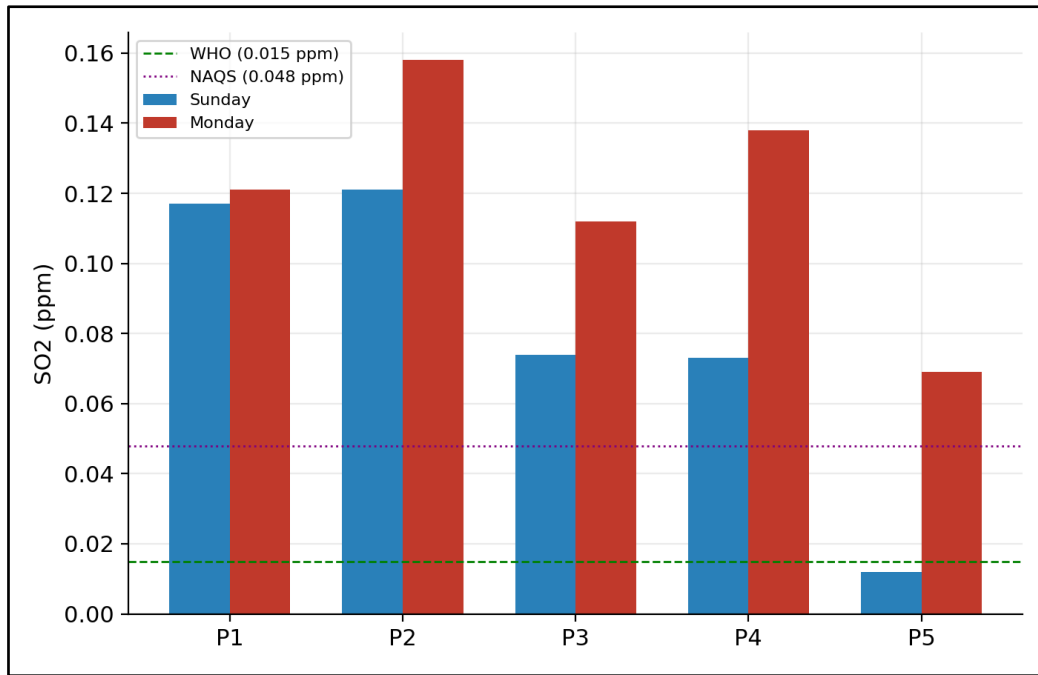


Figure 11: Weekend versus weekday Sulphur Dioxide (SO₂) by station

Across all three gaseous pollutants, Monday concentrations exceeded Sunday concentrations by 15-90%, with the largest relative increases recorded at P2, mirroring the pattern observed for particulate matter and reinforcing the conclusion that weekday commercial and inter-city traffic is the dominant driver of intersection-scale pollution in the study area.

3.3 Total Volatile Organic Compounds (TVOC)

TVOC concentrations, associated with fuel evaporation and incomplete combustion, were markedly higher at P2 (2.65 mg/m³) than at any other station - roughly 4.6 to 8.5 times the levels recorded at the other three intersections (P1: 4.6x; P3: 5.5x; P4: 8.5x) (Figure 12). This is consistent with the dense motorcycle and commercial-taxi traffic and fuel-vending activity historically associated with this junction, and suggests that fuel-handling and idling-related VOC emissions, rather than through-traffic alone, may be an important local contributor at this specific site.

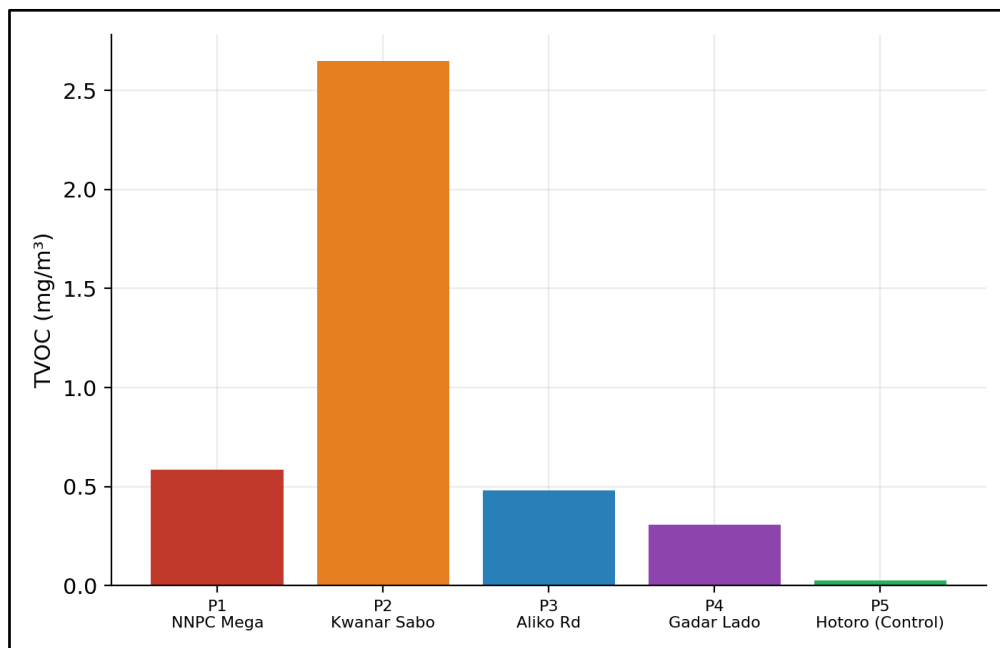


Figure 12: Overall mean TVOC concentration by station

3.4 Compliance with Air Quality Standards

Figure 13 summarizes pollutant-specific exceedance ratios (station mean concentration divided by the corresponding WHO guideline value) across all five stations, providing a unified view of relative severity across pollutant types.

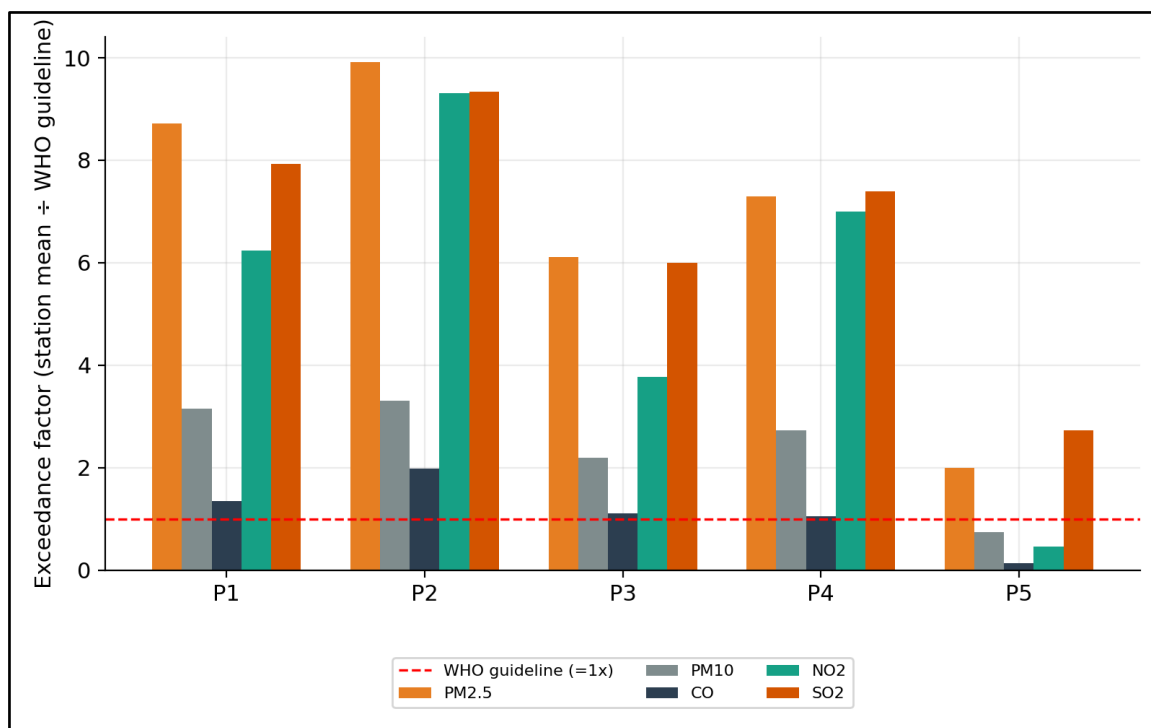


Figure 13: Pollutant exceedance ratios relative to WHO Air Quality Guidelines

PM_{2.5} and NO₂ emerge as the pollutants of greatest concern, with exceedance ratios reaching approximately 9.9x and 9.3x, respectively, at P2. CO showed the smallest relative exceedance, remaining close to or below the WHO guideline at P3, P4 and P5. The ranking P2 > P1 > P4 > P3 > P5 holds exactly for the particulate pollutants (PM_{2.5}, PM_{1.0}, PM₁₀) and for SO₂, while CO, NO₂ and TVOC show minor rank reversals between P1, P3 and P4 (e.g., P4 > P1 for NO₂; P3 > P4 for CO and TVOC) (Figure 13). This pattern nonetheless mirrors the traffic-control and geometric classification in Table 1: the signalized, partially enclosed four-way junction (P2) is the most polluted, the open T-junction (P3) is generally among the least polluted of the four intersections, and the residential control site (P5) is consistently and substantially cleaner than any intersection.

This consistent elevation of pollutant concentrations at intersections relative to the control site (by factors of roughly 3.5x to 8.6x depending on pollutant) confirms that vehicular traffic is the dominant local source of air pollution at the studied locations, in agreement with comparable studies conducted at road junctions in Ogbomoso and Owerri, Nigeria (Nwankwo & Bamidele, 2025; Emereibeole et al., 2023) and in Warri Metropolis, where NO₂, SO₂, CO and PM₁₀ levels at major junctions similarly approached or exceeded national standards. The results further indicate that intersection geometry and control type modulate pollutant accumulation: the partially enclosed, signalized four-way junction (P2) consistently recorded the highest concentrations, plausibly reflecting a street-canyon effect that traps pollutants and repeated stop-start cycling at the signal, while the open three-way T-junction (P3) allowed comparatively better dispersion. This is consistent with findings that intersection geometry meaningfully affects urban air pollution management outcomes (Šarić et al., 2023).

4. CONCLUSION

This study assessed traffic-related air quality at four major road intersections and one residential control site in Tarauni Local Government Area, Kano State, over an eight-week harmattan-season campaign. The results show that road intersections are significant, geometry- and control-dependent pollution hotspots, with PM_{2.5}, PM_{1.0}, PM₁₀, NO₂ and SO₂ concentrations consistently exceeding WHO

Air Quality Guidelines - and, for $\text{PM}_{2.5}$ and NO_2 in particular, frequently exceeding the more permissive Nigerian Ambient Air Quality Standards as well. The signalized, partially enclosed Kwanar Sabo intersection (P2) recorded the highest pollution levels across nearly all parameters, while the open T-junction (P3) recorded the lowest among the four intersections, underscoring the influence of junction geometry on local air quality. Weekday concentrations were consistently higher than weekend concentrations, and evening peak periods recorded the highest pollutant loads, confirming that vehicular traffic volume and congestion are the principal drivers of intersection-scale air pollution in the study area. These findings highlight an urgent need for targeted traffic management, vehicle emission control and continuous air quality monitoring at major Kano intersections to protect the health of commuters, roadside traders and traffic personnel.

A key limitation of this study is that sampling was confined to the harmattan season (mid-December 2025 to mid-February 2026), a period characterized by elevated regional background particulate loading from Saharan dust intrusion. Because harmattan-season background PM levels are substantially higher than during the wet season, the absolute pollutant concentrations and exceedance ratios reported here may not be representative of year-round conditions, and the relative contribution of traffic versus meteorology to observed pollution levels cannot be fully disentangled from a single-season campaign. Findings on comparative station rankings and weekday/weekend or diurnal contrasts are likely more robust to this limitation than the absolute concentration values, since traffic patterns rather than dust loading primarily drive these relative differences. Future work should extend monitoring across seasons, including the wet season, and incorporate traffic-count data to more precisely apportion intersection pollution between exhaust emissions and non-exhaust road-dust resuspension.

5. RECOMMENDATIONS

- Deploy intelligent/adaptive traffic signal systems at high-volume junctions (notably P1 and P2) to reduce idling time and queue lengths.
- Enforce regular vehicle inspection and emission-testing programmes, with priority given to the heavy-duty and inter-city fleet using the A2/A3 corridors.
- Improve road-surface conditions at unsignalized junctions to reduce dust resuspension contributing to PM_{10} loading.
- Establish vegetative buffer zones and roadside green belts between major intersections and adjacent residential and commercial areas.
- Install permanent, continuous air quality monitoring stations at the most heavily polluted junctions to support real-time public health advisories.
- Extend future monitoring across the wet season to separate meteorological (harmattan dust) from traffic-driven contributions to particulate matter.

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