



Noise and Air Quality from Traffic in Mueang Nakhon Si Thammarat, Nakhon Si Thammarat Province

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Abstract: Noise pollution and poor air quality are growing environmental concerns in rapidly developing Thai cities. This study assessed traffic-generated noise levels and ambient air quality at four signalized intersections in Mueang Nakhon Si Thammarat district, Nakhon Si Thammarat Province, in September 2022. Measurements were conducted at three peak-hour periods (07:00–09:00, 11:00–13:00, and 15:00–17:00) on both weekdays and weekends. Parameters included equivalent continuous noise level (Leq), oxygen (O₂), carbon monoxide (CO), carbon dioxide (CO₂), sulfur dioxide (SO₂), relative humidity, wind speed, and temperature. All four sites exceeded the Thai national noise standard (24-hr average ≤ 70 dB(A)) on weekdays, with Site 1 (Hua Thanon) recording the highest average of 73.5 dB(A). On weekends, Site 2 (Fountain Circle–Kanlayanee School) was the only site within the standard at 69.9 dB(A). CO concentrations at all sites (26.0–27.3 ppm) exceeded the Thai 8-hour ambient standard of 9 ppm, though they remained within the 1-hour limit of 30 ppm. O₂ levels were below the atmospheric reference of 20.9% at every site, while SO₂ was undetectable throughout. Environmental factors—particularly relative humidity, wind speed, and temperature—influenced both noise propagation and pollutant dispersion. Site 3 (Khu Khwang) showed the highest CO and CO₂ concentrations, attributed to the dense surrounding buildings, which restricted ventilation. These findings highlight the need for continuous environmental monitoring and traffic management interventions in Nakhon Si Thammarat's urban core.

Keywords: Traffic noise; air quality; carbon monoxide; urban environment; Nakhon Si Thammarat

1. Introduction

Noise pollution has emerged as a significant environmental issue, particularly in large cities and densely populated communities that serve as centers of economic activity. Transportation, especially road traffic from motorcycles, automobiles, and modified-exhaust vehicles, is widely recognized as the predominant source of urban noise. In Thailand, comparative data from 2022 show that motorcycles and automobiles remain the primary noise-generating sources, with adverse consequences for the health of residents and passersby [1]. In the Southern Region of Thailand, continuous monitoring has recorded noise levels ranging from 52.2 to 86.3 dB(A), exceeding the 24-hour Leq standard, with values trending upward, especially in the Phuket municipality, where recreational activities near tourist attractions amplify traffic noise. Simultaneously, ambient air quality monitoring for the five major pollutants (SO₂, NO₂, CO, PM₁₀, and O₃) has generally been classified as satisfactory in the

South [2]. Beyond road traffic, noise monitoring research in Thailand has expanded to include emerging sources such as utility-scale wind power plants, where sound pressure levels and propagation zones require systematic field assessment [3, 4], and engineering interventions such as noise barriers incorporating agricultural residues have demonstrated measurable attenuation potential in local settings [5]. These studies collectively underscore the growing recognition that acoustic environmental management demands source-specific methodologies.

Nakhon Si Thammarat Province is the most populous province in Southern Thailand and the 16th largest in the country by area. As a historically and economically significant city that attracts both domestic and international tourists through landmarks such as Wat Phra Mahathat Woramahawihan, Khanom–Mu Koh Thale Tai National Park, and Ai Khai Temple, the province has experienced substantial economic expansion. This growth has directly increased vehicular traffic, particularly at signalized intersections in the urban district, where congestion during school rush hours may push noise and air pollution beyond legally defined thresholds [6, 7]. Despite these concerns, systematic data on traffic-generated environmental pollution at key intersections in Nakhon Si Thammarat remain limited. Advances in real-time monitoring technology, including AIoT-based systems capable of predicting PM_{2.5} concentrations in urban environments, highlight both the feasibility and urgency of continuous, multi-parameter air quality surveillance at high-traffic locations [8]. Earlier work by Srikaew and Tonsoom examined air quality and noise levels at a parking facility in the city, documenting O₂ levels below standard and CO concentrations exceeding the 8-hour limit [9]. Building on that foundation, the present study undertakes a comprehensive assessment at four major signalized intersections in Mueang district, comparing measured values against national ambient standards and examining the role of meteorological factors in modulating pollution levels. Traffic signal optimization research – including simulation-based analyses of heterogeneous traffic flows at signalized intersections [10], further confirms that intersection management directly determines vehicle idle time and, therefore, emission accumulation, reinforcing the need for simultaneous noise and air quality characterization at such sites.

The objectives of this study were: (1) to measure noise levels and concentrations of O₂, CO, CO₂, and SO₂ at the four intersections on both weekdays and weekends; (2) to compare measured values with the standards prescribed by National Environmental Board Notifications No. 15 (B.E. 2540) for noise and No. 10 (B.E. 2538) and No. 21 (B.E. 2544) for air quality; and (3) to evaluate the influence of environmental factors, relative humidity, wind speed, and temperature, on observed noise and air quality levels.

2. Materials and Methods

2.1 Study Area and Sampling Sites

The study was conducted at four signalized intersections in Mueang Nakhon Si Thammarat district (Figure 1). Site 1 – Hua Thanon intersection, Tambon Ma Muang Song Ton (coordinates: 47P, x = 607092, y = 926579). Site 2 – Fountain circle roundabout in front of Kanlayanee Si Thammarat School, Ratchadamnoen Road, Tambon Khlang (47P, x = 606027, y = 932004). Site 3 – Khu Khwang intersection, Phatthanakan Khu Khwang Road, Tambon Tha Wang (47P, x = 606751, y = 933176). Site 4 – Benjamachutit intersection, Tambon Phot Sadet (47P, x = 601469, y = 932394). The area is characterized by a coastal plain topography and a tropical monsoon climate (hot season: February–April; rainy season: May–October, influenced by the southwest monsoon; November–January, influenced by the northeast monsoon). Site 3 is notable for being flanked by tall buildings that constrain air circulation, unlike the other three intersections.

2.2 Measurement Schedule

Data were collected in September 2022 (one weekday and one weekend day per site, for a total of 8 days). At each site, measurements were taken during three peak-traffic periods: Period 1 (07:00–09:00), Period 2 (11:00–13:00), and Period 3 (15:00–17:00). Within each period, readings were recorded at 15-minute intervals, with instruments initialized 15 minutes before data collection commenced. Each 15-minute reading represents the mean equivalent noise level (Leq) recorded continuously over the 15-minute window, along with the mean gas concentration averaged over the same interval.

2.3 Measurement Equipment

The instruments used are summarized in Table 1. The sound level meter was set to Fast response mode and A-weighting to record Leq, Leq Min, and Leq Max values. The microphone was mounted at 1.2–1.5 m above ground level at the roadside edge and oriented toward the traffic flow, in accordance with the Pollution Control Department (PCD) guidelines [11]. No reflective surfaces existed within a 3.5 m radius of the microphone.

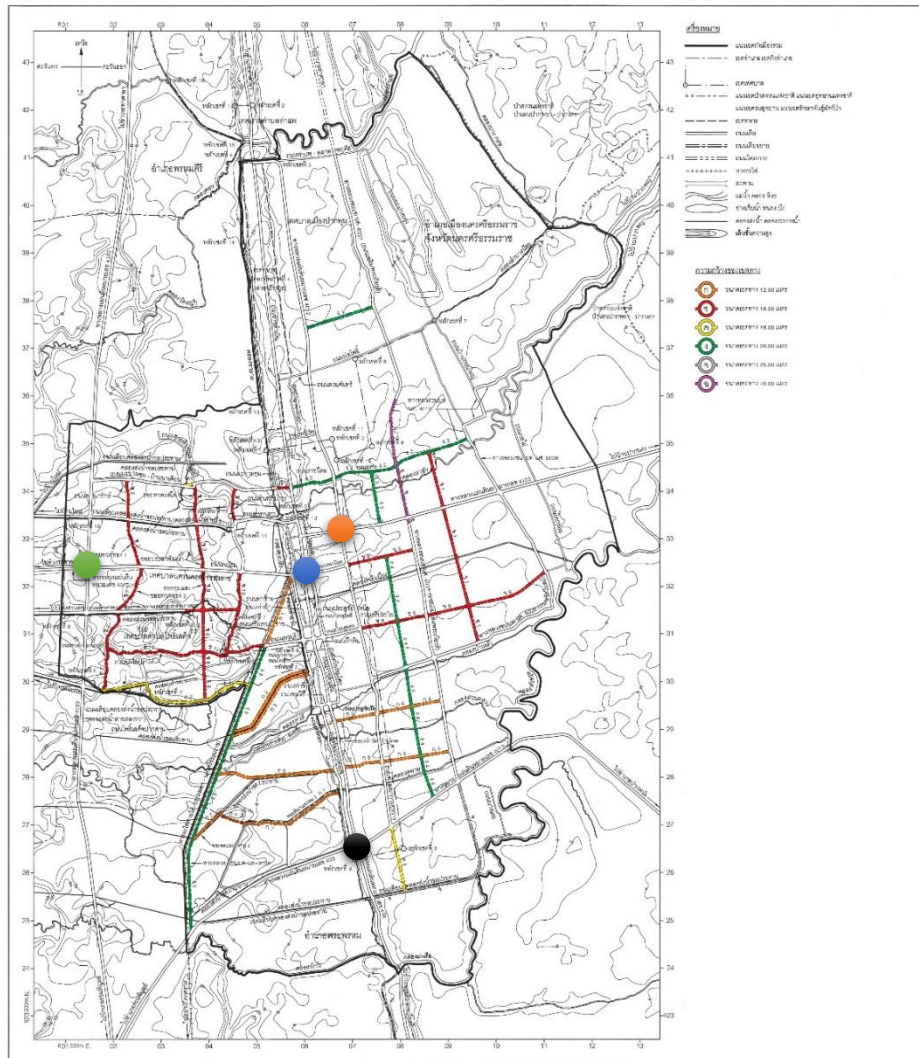


Figure 1. Locations of the four signalized intersection monitoring sites in Mueang Nakhon Si Thammarat district. Base map adapted from the Ministry of Interior (Transportation Network Plan appended to the Ministerial Regulation Enforcing the Nakhon Si Thammarat City Plan). The authors added the site locations for monitoring.

Table 1. Instruments used for field data collection.

Equipment	Specification / Parameter Measured
Sound Level Meter (Type 2)	Noise level (dB(A)); A-weighting; Leq, Leq Min, Leq Max; range 30–130 dB
DIGICON DO-552	Oxygen (O ₂) concentration (0–30%), temperature (0–50°C)
Extech CO250	Carbon dioxide (CO ₂) concentration (ppm)
Extech CO10	Carbon monoxide (CO) concentration (ppm)
Gasbadge Pro-O2	Sulfur dioxide (SO ₂) concentration (ppm)
Dry-Wet 5538285 Hygrometer	Relative humidity (%)
DIGICON DA-47 Anemometer	Wind speed (m/s)

2.4 Data Analysis

Noise data were compared with the Thai General Noise Standard (National Environmental Board Notification No. 15, B.E. 2540): $\text{Leq}_{24\text{-hr}} \leq 70 \text{ dB(A)}$ and $\text{Lmax} \leq 115 \text{ dB(A)}$ [12]. Air quality data were compared against the Thai Ambient Air Quality Standard (National Environmental Board Notifications No. 10, B.E. 2538, and No. 21, B.E. 2544): $\text{CO } 1\text{-hr} \leq 30 \text{ ppm}$, $\text{CO } 8\text{-hr} \leq 9 \text{ ppm}$; $\text{SO}_2 \text{ } 1\text{-hr} \leq 0.30 \text{ ppm}$, $\text{SO}_2 \text{ } 8\text{-hr} \leq 0.12 \text{ ppm}$ [13]. Descriptive statistics (mean, minimum, maximum) were calculated for each site, period, and day type. The influence of relative humidity, wind speed, and temperature on noise and air quality was assessed qualitatively. A formal correlation or regression analysis was not conducted owing to the limited number of independent measurement sessions; this is acknowledged as a limitation, and future studies with larger datasets should apply Pearson or Spearman correlation coefficients to quantify these relationships.

3. Results and Discussion

3.1 Noise Levels

Table 2 presents the summary noise levels for all four sites. On weekdays, average noise levels (Leq) at all sites exceeded the 70 dB(A) standard, ranging from 70.3 dB(A) (Site 2) to 73.5 dB(A) (Site 1). On weekends, three of the four sites still exceeded the standard; Site 2 was the sole exception at 69.9 dB(A). Maximum noise levels (Leq Max) at all sites and all periods remained well below the 115 dB(A) limit.

Table 2. Summary of average noise levels (dB(A)) by site and day type. * Exceeds the 70 dB(A) national standard.

Site	Weekday Leq Min (dB(A))	Weekday Leq Max (dB(A))	Weekday Avg (dB(A))	Weekend Leq Min (dB(A))	Weekend Leq Max (dB(A))	Weekend Avg (dB(A))
Site 1 – Hua Thanon	61.2	85.8	73.5*	61.6	80.5	71.1*
Site 2 – Fountain Circle (Kanlayanee)	59.5	81.0	70.3*	59.7	80.0	69.9
Site 3 – Khu Khwang	60.1	81.1	70.6*	61.1	79.7	70.4*
Site 4 – Benjarachutit	62.5	80.8	71.7*	60.7	80.1	70.4*

Site 1 (Hua Thanon) consistently recorded the highest noise on both weekdays (73.5 dB(A)) and weekends (71.1 dB(A)). This is attributable to the site's pronounced road gradient, which compels drivers to accelerate their engines while waiting at the traffic light or traversing the slope, thereby generating higher engine noise than at flat-grade intersections. A similar pattern was reported by Suphakit et al. [14] for heavy-traffic intersections in Kamphaeng Phet municipality, where peak-hour Leq values reached 70.2 dB(A). Site 2 (Fountain Circle–Kanlayanee) showed the lowest noise on both day types, partly because weekend traffic volume is substantially lower than at the adjacent educational establishments. This outcome aligns with findings from Ariya et al. [15], who observed that daytime noise at Khon Kaen signalized intersections consistently exceeded 70 dB(A) on working days but varied more on weekends. The observed weekday–weekend difference across all sites ranged from 0.2 to 2.4 dB(A), consistent with findings by Wallika [16] and Niran [17], who both report that weekday Leq values in school and university environments exceed those on weekends. Relative humidity was the most significant environmental modifier of noise levels. Higher humidity reduces the air's capacity to absorb sound, resulting in louder perceived noise. Simultaneously, wind speed influences sound wave propagation, and temperature, which is inversely proportional to relative humidity, modulates sound refraction. At Site 2, slightly higher wind speed on weekends (0.9 m/s vs. 0.8 m/s on weekdays) may have marginally enhanced sound dissipation, contributing to its within-standard weekend reading.

Figure 2 illustrates the pattern of noise levels across measurement periods and sites for both weekdays and weekends. As shown in panel (a), noise levels during Period 1 (07:00–09:00) were generally the highest across most sites on weekdays, reflecting the morning school and commuter rush hour that generates dense, slow-moving traffic at all four intersections. Site 1 (Hua Thanon) recorded the highest Period 1 weekday value of 74.2 dB(A), while noise levels remained relatively stable across Periods 2 and 3 (73.4 and 73.0 dB(A), respectively), suggesting sustained traffic intensity throughout the working day rather than a single

pronounced peak. Panel (b) confirms that Site 1 consistently produced the highest overall average noise on both weekdays (73.5 dB(A)) and weekends (71.1 dB(A)), with all values exceeding the national 24-hour standard of 70 dB(A) denoted by the dashed reference line. Site 2 (Fountain Circle–Kanlayanee School) was the only site to fall within the standard on weekends (69.9 dB(A)), a reduction attributable to the absence of school-related traffic on non-working days and to comparatively higher wind speed (0.9 m/s), which aided sound dissipation. Sites 3 and 4 exhibited very similar overall averages on weekends (70.4 dB(A) each), marginally exceeding the standard, while their weekday averages (70.6 and 71.7 dB(A), respectively) reflected the combined effect of commuter traffic and restricted ventilation, particularly at Site 3, where surrounding buildings limit sound attenuation. Across all sites, weekday noise averages were consistently higher than weekend values by 0.2 to 2.4 dB(A), a difference driven primarily by the higher volume and density of vehicular traffic on working days. This weekday–weekend differential is consistent with findings reported in comparable urban intersection studies in Thailand and internationally [14–16].

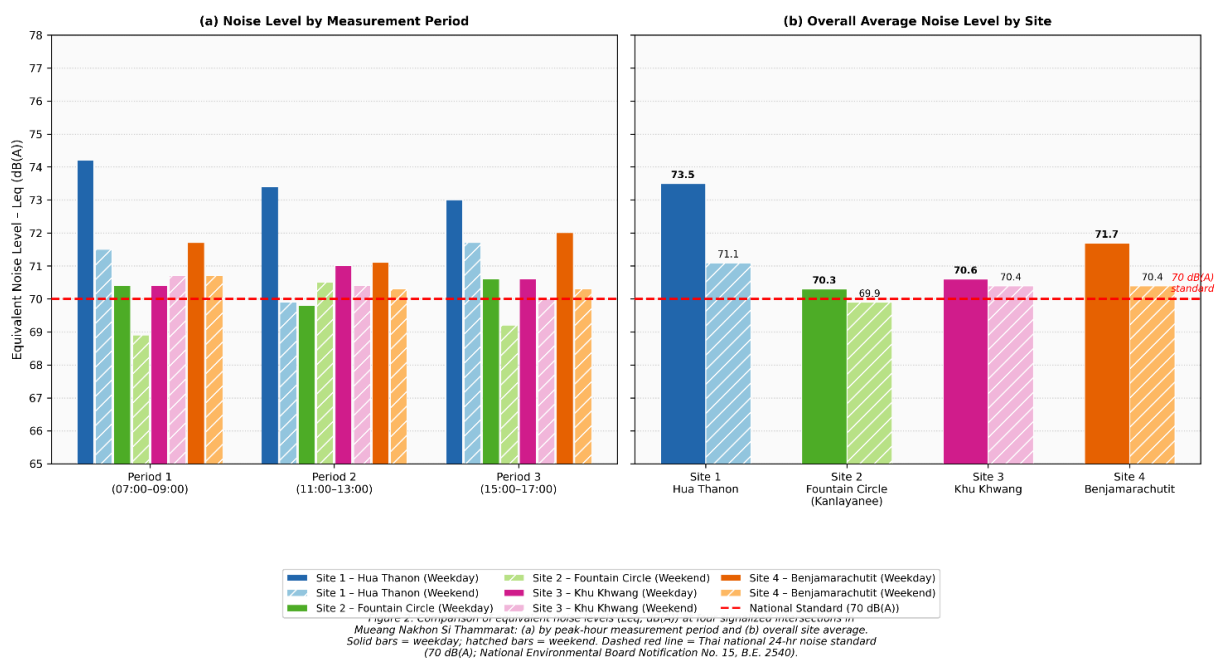


Figure 2. Comparison of average equivalent noise levels (Leq, dB(A)) at four signalized intersections in Mueang Nakhon Si Thammarat on weekdays and weekends across three peak-hour measurement periods (Period 1: 07:00–09:00, Period 2: 11:00–13:00, Period 3: 15:00–17:00). The dashed horizontal line indicates the Thai national 24-hour noise standard of 70 dB(A) (National Environmental Board Notification No. 15, B.E. 2540).

3.2 Air Quality

Table 3 summarizes the mean air quality parameters for all four sites by day type. Figures 3 and 4 provide visual comparisons of O_2 , CO, and CO_2 concentrations across sites and day types. Sulfur dioxide was undetectable at all sites and all measurement periods, consistent with the relatively clean fuel standards in modern Thai vehicles and the absence of heavy industry in the immediate vicinity. O_2 concentrations were below the atmospheric reference value of 20.9% at every site and period, as shown in Figure 3(a), with the lowest average recorded at Site 3 on weekdays (14.8%). The cause of these anomalously low O_2 readings warrants caution in interpretation. A depletion of 5–6 percentage points below the 20.9% atmospheric reference cannot be accounted for quantitatively by the co-measured CO (~27 ppm) and CO_2 (~600 ppm), which together displace less than 0.1% of atmospheric O_2 ; such large deficits are physically implausible at open outdoor intersections. The most probable explanation is calibration drift or sensor error in the DIGICON DO-552; calibration records should be verified. The O_2 data are reported here for completeness but should be interpreted with caution, and no mechanistic conclusions about combustion gas displacement are drawn from these values.

Table 3. Mean air quality concentrations by site and day type (ND = not detected). * CO 8-hr average exceeds the 9 ppm national standard at all sites.

Parameter	Site 1 Hua Thanon	Site 2 Fountain Circle	Site 3 Khu Khwang	Site 4 Benjamarachutit	Standard (1-hr avg)	Standard (8-hr avg)
<i>Weekday</i>						
O ₂ (%)	15.1	15.1	14.8	17.2	N/A (ref: 20.9%)	N/A
CO (ppm)	26.6	26.1	27.2	26.6	≤30 ppm	≤9 ppm*
CO ₂ (ppm)	562	565	627	587	N/A	N/A
SO ₂ (ppm)	ND	ND	ND	ND	≤0.30 ppm	≤0.12 ppm
<i>Weekend</i>						
O ₂ (%)	15.3	15.3	15.3	18.4	N/A	N/A
CO (ppm)	26.5	26.0	27.3	26.7	≤30 ppm	≤9 ppm*
CO ₂ (ppm)	536	605	552	564	N/A	N/A
SO ₂ (ppm)	ND	ND	ND	ND	≤0.30 ppm	≤0.12 ppm

CO concentrations ranged from 26.0 to 27.3 ppm across all sites and day types, as shown in Figure 3(b). While these values satisfy the 1-hour limit of 30 ppm, they substantially exceed the Thai 8-hour ambient standard of 9 ppm prescribed by the National Environmental Board. It is important to note, however, that the 8-hour TWA standard applies to a continuous 8-hour average, whereas the measurements here were conducted during three separate 2-hour peak periods. A direct comparison is therefore approximate: these peak-period concentrations substantially exceed the 8-hour standard, suggesting the 8-hour TWA may also be exceeded on heavy-traffic days, but this cannot be confirmed without continuous monitoring. All measured CO values fall within the shaded zone between the two standards, underscoring that although no acute 1-hour exceedance occurred, prolonged exposure during peak periods represents a potential chronic health concern for traffic officers and pedestrians stationed at these intersections. The elevated CO reflects the accumulation of exhaust gases during red-light idle periods at all four intersections. Site 3 recorded the highest mean CO on weekdays (27.2 ppm) and weekends (27.3 ppm). The tall buildings surrounding Site 3 impede horizontal air circulation, trapping emissions within the intersection canyon and explaining the elevated CO and CO₂ levels discussed below. The effect of restricted ventilation associated with adjacent tall buildings on pollutant accumulation is well documented and is consistent with the ventilation analysis in this study [13, 18]. Formal characterization of Site 3 as a street canyon (typically requiring a building height-to-road-width ratio $H/W > 0.5$) was not conducted because building height and road-width data were not collected; this is acknowledged as a limitation and recommended for future study. Figure 4 illustrates the spatial and temporal variability of CO₂ concentrations across sites and measurement periods. As shown in panel (a), Period 1 (07:00–09:00) consistently produced the highest CO₂ readings at most sites on weekdays, particularly at Site 3 (671.0 ppm) and Site 4 (626.0 ppm), reflecting the accumulation of exhaust gases during the morning commuter rush before daytime heating and wind speed increases facilitate dispersion. A notable anomaly was observed at Site 2 during Weekend Period 1, which recorded the highest single-period CO₂ value of 711.4 ppm. This is likely attributable to a localized episode of low wind speed (0.5 m/s) combined with elevated relative humidity (86.3%) on that measurement day, suppressing pollutant dispersion in the early morning hours before temperature-driven convection became active. Panel (b) confirms that Site 3 recorded the highest overall weekday CO₂ average of 627.4 ppm, the maximum of all sites and day types, while Site 1 recorded the lowest weekday average of 562.1 ppm. On weekends, Site 2 produced the highest average (604.7 ppm) and Site 1 the lowest (535.7 ppm). CO₂ has no applicable Thai ambient air quality standard or WHO health-based outdoor exposure limit; it is used here as a tracer of vehicle exhaust accumulation rather than as a regulated pollutant. All measured CO₂ values considerably exceeded the global outdoor background level of approximately 420 ppm, reflecting the substantial near-road enhancement attributable to vehicular exhaust at urban signalized intersections. Environmental factors, particularly relative humidity, wind speed, and temperature, played a

consistent secondary role in modulating CO₂ levels. Higher relative humidity on weekdays suppressed temperature and reduced gaseous dispersion efficiency, while higher weekend wind speeds at some sites transported pollutants away from the measurement point, contributing to lower CO readings. When the temperature rose at lower humidity, CO₂ expanded and became lighter than ambient air, tending to rise and resulting in lower near-ground readings, a phenomenon consistent with established atmospheric chemistry principles [19]. Site 4 (Benjamarachutit) recorded the highest O₂ concentrations on both weekdays (17.2%) and weekends (18.4%), reflecting its more open topography and higher background wind speeds that facilitate oxygen replenishment and pollutant dilution. Conversely, CO₂ at Site 4 was 589.7 ppm on weekdays, lower than at Site 3, confirming its better ventilation capacity. Comparable CO₂ ranges of 500–700 ppm have been reported at near-road urban sites in studies from both Thai and international urban settings [20].

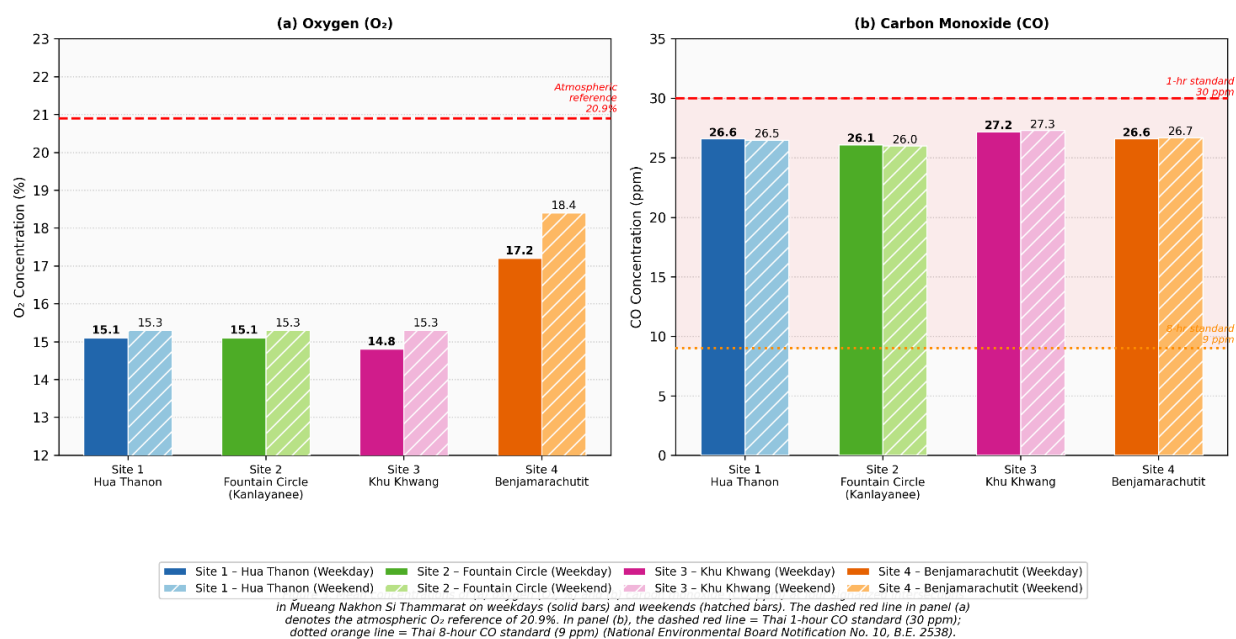


Figure 3. Mean concentrations of (a) oxygen (O₂, %) and (b) carbon monoxide (CO, ppm) at four signalized intersections in Mueang Nakhon Si Thammarat on weekdays and weekends. The dashed line in panel (a) indicates the atmospheric reference value of 20.9% O₂. The dashed lines in panel (b) indicate the Thai national 1-hour standard (30 ppm) and 8-hour standard (9 ppm) (National Environmental Board Notification No. 10, B.E. 2538, and No. 21, B.E. 2544).

3.3 Comparative Assessment with Previous Studies

Table 4 and Figure 5 place the present findings in the context of comparable traffic environmental studies conducted in Thailand and internationally. As shown in Table 4, noise levels at signalized intersections and near-road sites consistently exceed national or WHO-recommended standards across diverse geographic settings, confirming that traffic noise is a near-universal urban environmental challenge rather than a problem specific to any single region. Within Thailand, the present results are closely comparable to those of Suphakit et al. [14], who reported weekday Leq values of 68.5–70.2 dB(A) at four dense-traffic intersections in Kamphaeng Phet municipality, and to Ariya et al. [15], who recorded 68.7–73.0 dB(A) at signalized intersections in Khon Kaen. The most directly relevant Thai study is that of Srikaew and Tonsom [5], conducted at a commercial plaza car park in the same city as the present study, which reported an average Leq of 70.9–72.1 dB(A) and CO concentrations of 21.3–21.9 ppm. The higher CO values observed in the present study (26.0–27.3 ppm) likely reflect the more open outdoor intersection environment, where vehicles idle repeatedly at traffic signals rather than performing the shorter maneuvers typical of a parking facility. Nayan et al. [21], studying school roadsides in Malaysia, recorded Leq values of 57.7–76.1 dB(A), with all sites exceeding the Malaysian DOE standard of 60 dB(A), reinforcing the finding that proximity to educational institutions and peak school-travel hours amplifies intersection noise — a pattern clearly observed at Site 2 of

the present study on weekdays. Internationally, Gheibi [22] documented Leq values of 72.75–78.0 dB(A) along approach roads to the Imam Reza Shrine in Mashhad, Iran, with the highest levels occurring during the afternoon peak when visitor density was greatest, consistent with the present study's observation that Period 3 (15:00–17:00) noise levels at Site 4 reached 72.0 dB(A) on weekdays. Goshu and Gosa [18] reported the highest noise levels in the comparative set, with Leq values of 80.0–87.5 dB(A) in a congested Ethiopian city market, reflecting the combined effects of mixed traffic, including minibusses, three-wheelers, and amplified loudspeakers, source types absent from the present study area. Ahmed Ali et al. [20] found noise averages of 63.2–83.8 dB(A) at near-road residential sites in Fallujah, Iraq, attributing exceedances partly to irregular generator use and commercial activity beyond standard traffic, again highlighting the role of non-traffic sources in amplifying near-road noise in developing-city contexts.

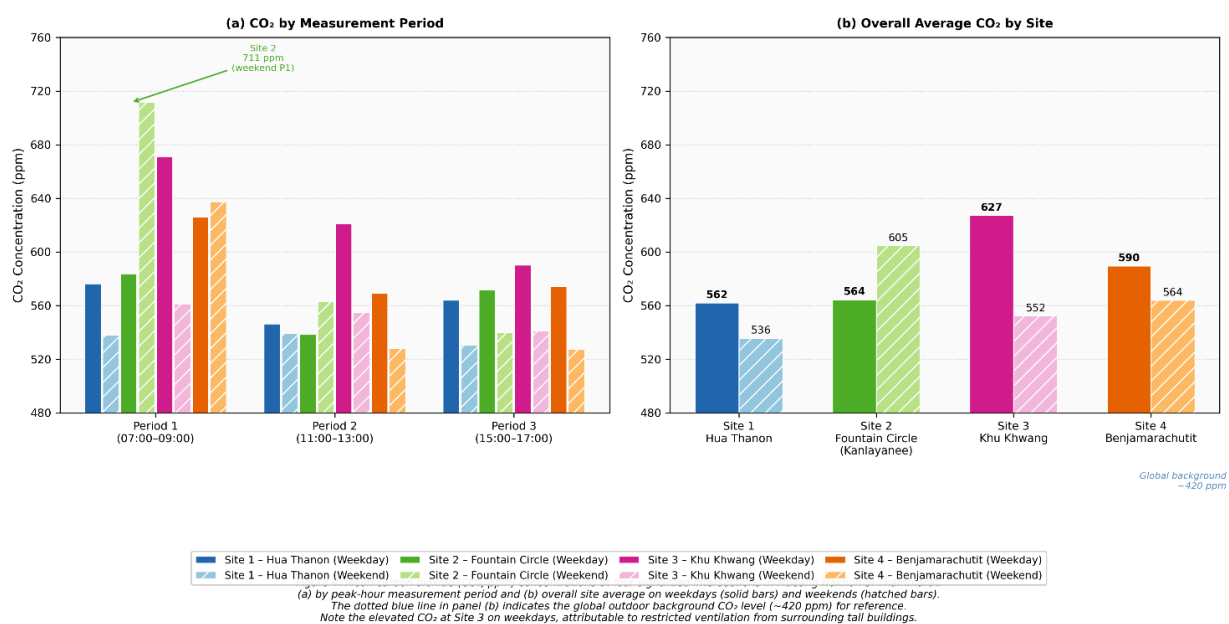


Figure 4. Mean carbon dioxide (CO₂, ppm) concentrations at four signalized intersections in Mueang Nakhon Si Thammarat across three peak-hour measurement periods on weekdays and weekends. Error bars represent the range of values within each period.

Figure 5 provides a multidimensional radar visualization comparing the present study with five selected prior studies across five performance dimensions: peak noise level relative to the standard, CO exceedance ratio, spatial coverage (number of sites), weekday–weekend noise differential, and breadth of environmental parameters measured. The radar chart highlights that, while the present study's absolute noise levels are moderate within the global comparison, lower than the Ethiopian and Iraqi studies but comparable to other Thai and Malaysian work, it is distinguished by the simultaneous characterization of four gaseous air quality parameters alongside noise and three meteorological covariates. Most prior studies in the comparison measured noise in isolation, limiting their ability to assess the compounded environmental burden experienced by road users and nearby residents. The present study's integrated approach, measuring both acoustic and chemical pollution at the same sites and times, therefore represents a methodological advance over single-parameter assessments and provides a more complete evidence base for environmental management decisions in Nakhon Si Thammarat. Taken together, the comparative evidence confirms three consistent patterns: (1) traffic noise at signalized urban intersections routinely exceeds national standards in both developed and developing countries; (2) CO concentrations at idle-heavy sites such as red-light intersections can exceed the 8-hour ambient standard even when remaining within the 1-hour limit; and (3) environmental factors, particularly wind speed, humidity, and urban morphology, are critical determinants

of both noise propagation and pollutant accumulation that must be accounted for in site-specific assessments and management strategies.

Table 4. Comparison of traffic-generated noise levels and CO concentrations reported in selected studies from Thailand and internationally, with findings from the present study.

Study	Location	Site Type	Noise Leq (dB(A))	CO (ppm)	Standard Exceedance
Suphakit et al. [9] (2017)	Kamphaeng Phet, Thailand	Urban intersections	68.5–70.2	—	Noise: borderline
Ariya et al. [10] (2018)	Khon Kaen, Thailand	Signalized intersections	68.7–73.0	—	Noise: yes (weekday)
Srikaew & Tonsoom [5] (2019)	Nakhon Si Thammarat, Thailand	Parking plaza	70.9–72.1	21.3–21.9	Noise: yes; CO: 8-hr yes
Nayan et al. [16] (2021)	Muallim, Perak, Malaysia	School roadsides	57.7–76.1	—	Noise: yes
Gheibi [17] (2021)	Mashhad, Iran	Shrine approach roads	72.75–78.0	—	Noise: yes
Goshu & Gosa [13] (2021)	Jimma, Ethiopia	Market area roads	80.0–87.5	—	Noise: yes
Ahmed Ali et al. [14] (2020)	Fallujah, Iraq	Residential near-road	63.2–83.8	—	Noise: yes
Present study (2022)	Nakhon Si Thammarat, Thailand	Signalized intersections	69.9–73.5	26.0–27.3	Noise: yes (3/4 sites); CO 8-hr: yes (all)

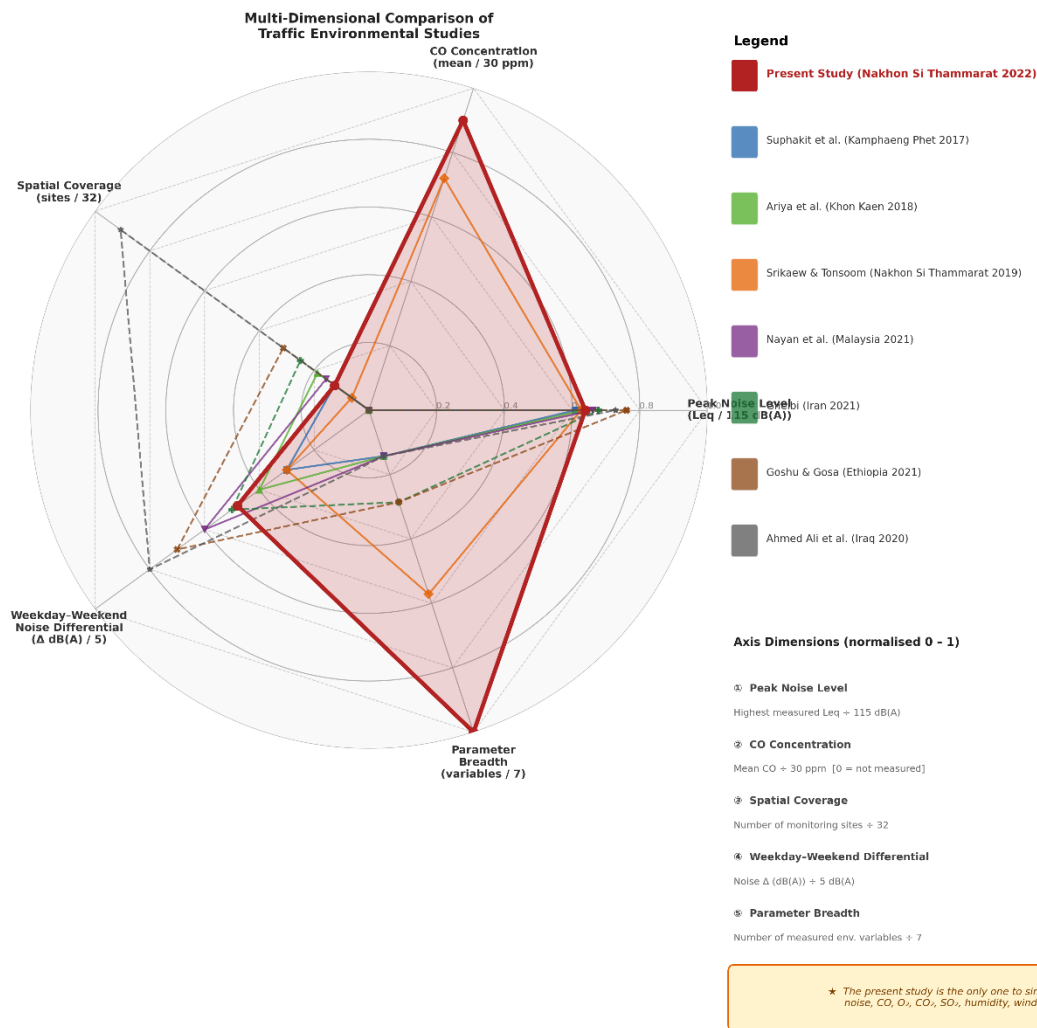


Figure 5. Multi-dimensional radar chart comparing the present study with seven selected traffic environmental studies from Thailand and internationally across five normalised axes: ① Peak Noise Level (highest measured Leq ÷ 115 dB(A)); ② CO Concentration (mean CO ÷ 30 ppm; 0 = not measured); ③ Spatial Coverage (number of monitoring sites ÷ 32); ④ Weekday-Weekend Noise Differential (Δ dB(A) ÷ 5); and ⑤ Parameter Breadth (number of measured environmental variables ÷ 7). All axes are normalized to a 0–1 scale to enable cross-study comparison. The present study (bold red, shaded polygon) is distinguished by the simultaneous measurement of noise, four gaseous air quality parameters (O₂, CO, CO₂, SO₂), and three meteorological variables (relative humidity, wind speed, temperature), giving it the broadest parameter breadth of all studies in the comparison. Studies reporting noise only are assigned a CO axis value of zero. Data sources: [5, 9, 10, 13, 14, 16, 17].

4. Conclusions

This study provides the first systematic, multi-site assessment specifically targeting signalized intersections for simultaneous noise and air-quality characterization in Mueang Nakhon Si Thammarat. The principal findings are (1) Average noise levels exceeded the Thai 24-hour standard of 70 dB(A) at all four sites on weekdays, and at three of four sites on weekends. Site 1 (Hua Thanon) was the loudest on both day types due to road gradient effects that increase engine load. (2) Peak-period CO concentrations (26.0–27.3 ppm) substantially exceeded the Thai 8-hour ambient standard of 9 ppm at all sites, while remaining within the 1-

hour limit of 30 ppm. Because measurements covered only 2-hour peak windows rather than a continuous 8-hour period, whether the 8-hour TWA standard is formally exceeded must be verified through continuous monitoring. SO₂ was undetectable. O₂ readings were below the atmospheric reference at every site but are subject to instrument calibration uncertainty and should be interpreted with caution. (3) Site 3 (Khu Khwang) recorded the highest CO and CO₂, attributable to restricted ventilation from adjacent tall buildings; formal street-canyon characterization (H/W ratio) was not conducted and is recommended for future study. Site 4 (Benjaminachutit) exhibited the best air quality, consistent with its more open topography. (4) Environmental factors—particularly relative humidity, wind speed, and temperature—significantly modulated both noise propagation and pollutant dispersion across sites and day types. These results highlight potential health risks for traffic officers and roadside workers with prolonged exposure at these intersections. It should be noted that N95 respirators are designed to filter particulate matter and are not effective against gaseous CO; appropriate personal protective equipment and health monitoring for workers should be determined through formal occupational health risk assessments that account for actual 8-hour TWA exposures. The relevant authorities are encouraged to implement continuous environmental monitoring, explore traffic management interventions such as signal re-timing and vehicle idling restrictions, and commission follow-up health impact assessments. Several important limitations of this study should be acknowledged. First, all data were collected in September 2022 (wet season only); seasonal variation in wind speed, humidity, temperature, and traffic patterns in southern Thailand means that dry-season and year-round monitoring is essential before broader conclusions about chronic exposure can be drawn. Second, traffic volume and vehicle-type composition data were not collected during measurement periods, limiting the ability to separate the effects of traffic volume from site morphology; future studies should incorporate concurrent traffic counts. Third, NO₂ and PM_{2.5}—two of the most health-relevant traffic pollutants with established Thai and WHO ambient standards—were not measured, and their absence is a significant methodological gap that future work must address. Fourth, the qualitative assessment of meteorological influences and the absence of formal statistical tests for weekday-weekend and inter-site comparisons are acknowledged as analytical limitations. Future research should extend measurements to 24 hours, apply continuous monitoring to verify 8-hour TWA exceedances, include PM_{2.5} and NO₂, conduct formal correlation and regression analysis, and quantify the health burden attributable to chronic noise and CO exposure at these intersections.

5. Acknowledgments

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