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Urban Environmental Noise in Tirana: Spatial and Temporal Patterns from Field Measurements at Three Major Traffic Junctions

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Abstract
Background: Road traffic noise is a major environmental concern in urban areas, contributing to noise pollution and affecting the quality of the urban environment. Objective: To characterize spatial and labelled time-of-day variability at three major traffic junctions in Tirana, Albania, using the underlying field-measurement workbook. Methods: Timestamped readings from Zogu i Zi, 21 Dhjetori, and Kamza Terminal were summarized descriptively using counts, arithmetic means, standard deviations, medians, and observed ranges. Measurements were collected using a Testo 816-1 sound-level meter and the Noise Capture smartphone application. Results: Across 8,400 readings from 45 labelled sessions, Zogu i Zi (n=2,700) had a mean of 65.21 dB (SD 4.22; range 47.9–93.5), 21 Dhjetori (n=2,700) 65.62 dB (SD 5.72; range 47.5–97.3), and Kamza Terminal (n=3,000) 67.54 dB (SD 3.32; range 37.1–89.9). The workbook also contains 600 separately described neighbourhood observations. Differences across labelled daytime periods were modest, but some headings and timestamps were inconsistent. Conclusions: These records offer a site-specific descriptive baseline. Arithmetic means cannot be designated LAeq (Equivalent Continuous Sound Level) or compared directly with long-term guideline indicators without verified measurement settings and sampling design.

Keywords: *urban noise; traffic junctions; Tirana; Albania; environmental acoustics; descriptive analysis; field monitoring*

Introduction

Environmental noise from transport is a major component of urban soundscapes. Traffic volume, fleet composition, vehicle acceleration, road surfaces and the geometry of surrounding buildings can influence the sound level at a measurement point. Research has linked sustained road traffic noise exposure with annoyance, sleep disturbance and cardiovascular outcomes; these population-level findings cannot be inferred from brief roadside readings (Basner et al., 2014; WHO, 2018; Münzel et al., 2018).

The European Environmental Noise Directive (END) establishes long-term indicators and strategic mapping requirements, while ISO 1996 provides a framework for describing and measuring environmental sound. The present study instead uses available timestamped field records to characterize sampled periods at three selected Tirana traffic nodes. Its contribution is to make the sample size, variability, and recorded sampling dates explicit, and to identify documentation gaps relevant to subsequent monitoring.

Road traffic noise and urban form

Road traffic noise is influenced by traffic volume and composition, acceleration and braking, vehicle speed, road-surface condition, junction geometry and the configuration of surrounding buildings. At busy intersections, relatively continuous traffic sound may be punctuated by short events such as horn use and the passage of heavy vehicles. Land-use patterns and proximity to residential or other noise-sensitive buildings affect potential exposure. These mechanisms provide a conceptual framework for interpreting the three Tirana junctions, but the present dataset contains no synchronized traffic counts, source annotations or building-geometry measurements that would permit causal attribution (WHO, 2018; EEA, 2020).

Road traffic noise and urban form

Evidence synthesized by Basner et al. (2014) links environmental noise exposure with annoyance, sleep disturbance and other auditory and non-auditory outcomes. Münzel et al. (2018) discuss potential cardiovascular pathways associated with chronic environmental noise. The WHO (2018) recommends reducing long-term road-traffic noise exposure below 53 dB Lden and 45 dB Lnight. These recommendations concern source-specific, long-term exposure indicators: they cannot be compared directly with arithmetic averages of short roadside readings. No health outcomes, individual exposure histories or residential receptor measurements were collected in this study.

Road traffic noise and urban form

The European Environmental Noise Directive (2002/49/EC) establishes common approaches to strategic noise assessment, public information and action planning, including Lden and Lnight indicators; it does not impose one universal EU-wide limit for every short field measurement. ISO 1996-1:2016 and ISO 1996-2:2017 provide principles for describing, measuring and assessing environmental sound. A regulatory compliance assessment for Albania would additionally require verification of applicable national provisions, land-use classification, prescribed indicators, and standardized measurement conditions. This article presents a descriptive field assessment, not a legal determination.

Literature review

Road traffic as a source of environmental noise

Road traffic is a major contributor to environmental noise in urban areas. Its acoustic profile depends not only on the volume of vehicles but also on fleet composition, operating speed, acceleration and braking, pavement condition, and the geometry of the street. At junctions, stop–start movements, queuing, and intermittent events may produce different sound patterns from those observed along uninterrupted road segments. The European Environment Agency (EEA, 2020) identifies transport noise as a substantial environmental concern across Europe and emphasizes the need to assess exposure at the population level. These factors provide a conceptual framework for examining environmental noise at Zogu i Zi, 21 Dhjetori and Kamza Terminal, offering insights into the spatial and temporal variations in noise levels across the selected urban locations.

Health effects and the importance of exposure duration

The public-health literature distinguishes the immediate acoustic characteristics of a measurement location from a person's cumulative exposure. Basner et al. (2014) review auditory and non-auditory effects of environmental noise, including annoyance and sleep disturbance, and describe evidence concerning cardiovascular and cognitive outcomes. Münzel et al. (2018) examine epidemiological and mechanistic research linking chronic environmental noise to cardiovascular pathways, including stress-related responses. These findings support environmental noise as a public-health research topic, but they do not establish health effects among people living or working near the three sampled Tirana junctions; this study did not measure personal exposure, residential sound levels, sleep or clinical outcomes.

The WHO Regional Office for Europe (2018) recommends reducing long-term road-traffic exposure below 53 dB Lden and 45 dB Lnight. Lden incorporates day, evening and night exposure with evening and night penalties, whereas Lnight represents night-time exposure over a long-term assessment period. Neither indicator can be reconstructed from the arithmetic means of the short, partly discontinuous field readings reported here. Consequently, WHO recommendations provide a rationale for more complete monitoring rather than a direct threshold test for this dataset. The measurements conducted at Zogu i Zi, 21 Dhjetori and Kamza Terminal provide empirical evidence of environmental noise conditions at three major traffic junctions in Tirana. Mean recorded sound levels ranged from 65.21 to 67.54 dB, with variations across monitoring locations and sampling periods. In the context of the WHO environmental noise guidelines, these findings highlight the relevance of urban traffic noise monitoring and provide a basis for further assessment of long-term exposure. Future monitoring incorporating evening and night-time measurements would enable a more comprehensive

evaluation using internationally recognized indicators such as Lden and Lnight.

Measurement indicators and methodological comparability

Environmental-noise research relies on clearly specified acoustic indicators and reproducible measurement conditions. ISO 1996-1:2016 establishes basic quantities and assessment procedures, while ISO 1996-2:2017 addresses determination of environmental sound-pressure levels. Energy-equivalent sound levels such as LAeq,T require defined frequency weighting, measurement duration, and energy-based averaging; the arithmetic mean of values already expressed in decibels is not automatically equivalent to LAeq,T. The measurement height and position, instrument settings, weather conditions, and calibration documentation also affect comparability across campaigns. These considerations are particularly important when comparing traffic junctions monitored on different dates or with more than one measurement instrument.

Environmental noise measurements in Tirana were conducted using both the Testo 816-1 sound-level meter and the Noise Capture smartphone application. The resulting dataset provides a substantial empirical basis for examining spatial and temporal variations in noise levels across the selected monitoring locations. The analysis focuses on descriptive statistics of the recorded sound levels, providing a clear characterization of the observed acoustic conditions and establishing a foundation for future standardized monitoring and comparative assessments.

European assessment and urban noise management

Directive 2002/49/EC, the Environmental Noise Directive, establishes a shared framework for assessing and managing environmental noise through strategic noise mapping, public information and action planning. It uses long-term indicators, including Lden and Lnight, to support comparisons and management decisions. The EEA (2020) places such assessment within a broader European picture of transport-related exposure and its consequences. Neither the Directive nor the WHO guidance provides a universal legal limit against which every short roadside observation can be assessed; any determination of regulatory compliance in Albania would additionally require the applicable national rules and prescribed measurement protocol.

For urban planning, the literature implies a progression from identifying potentially noisy locations to characterizing sources, estimating exposure at sensitive receptors and evaluating interventions. At intersections, potential measures may include traffic-flow management, changes to vehicle speed or composition, pavement maintenance and design changes, but their suitability depends on local evidence. The three-junction dataset is an initial descriptive step in that progression, not a before-and-after evaluation of any intervention.

Research gap and contribution of the Tirana case study

International evidence on traffic noise and health is extensive, but its findings cannot replace locally documented measurement protocols and site-specific observations. The present study contributes a transparent descriptive account of 8,400 timestamped readings collected at three selected Tirana traffic junctions, including the number of observations, recorded date coverage, variability, and labelled daytime patterns. It also identifies discrepancies between spreadsheet period headings and recorded timestamps. These strengths and limitations jointly define the research gap addressed here: establishing a reproducible local baseline and specifying the additional acoustic, traffic and temporal information required for future exposure-oriented studies.

Research objectives

The primary objective of this study is to assess the spatial and temporal variability of environmental noise at three major traffic junctions in Tirana: Zogu i Zi, 21 Dhjetori and Kamza Terminal. Drawing on a dataset of 8,400 recorded sound-level measurements, the research aims to provide a comprehensive descriptive assessment of noise conditions across the selected locations and establish an empirical baseline for future urban environmental monitoring.

More specifically, the study seeks to:

1. Characterize environmental noise levels at each monitoring location through a detailed statistical analysis of the recorded measurements, including arithmetic means, standard deviations, medians, and observed ranges.

2. Examine spatial differences in environmental noise across the three traffic junctions, identifying variations in average recorded sound levels, the distribution of measurements, and the occurrence of particularly high noise events.

3. Investigate temporal variability by analyzing measurements grouped into morning, midday, and afternoon periods, identifying patterns and differences in recorded sound levels throughout the sampled daytime sessions.

4. Assess the variability and intensity of recorded noise events, distinguishing between locations characterized by relatively consistent sound levels and those exhibiting greater fluctuations and pronounced individual readings.

5. Establish an empirical foundation for urban noise monitoring and management by identifying site-specific acoustic patterns and providing evidence to inform future monitoring programs, traffic-management measures and urban planning initiatives in Tirana.

By integrating spatial and temporal perspectives, the study contributes to a more detailed understanding of environmental noise conditions at major urban traffic junctions and supports the development of systematic, evidence-based approaches to environmental noise assessment in Tirana.

Materials and methods

Study sites and source data

The supplied Excel workbook contains four worksheets. Three named worksheets correspond to Zogu i Zi roundabout, 21 Dhjetori intersection, and Kamza Terminal junction. The fourth, labelled “Ne lagje” (“In the neighbourhood”), contains 600 readings but lacks sufficient documented site context for inclusion in the three-junction comparison; it is described separately in the supplementary data note. The junction records span 16 December 2024 to 17 February 2025 at the first two sites

and 17 December 2024 to 3 February 2025 at Kamza Terminal. The workbook groups readings into weekday columns and nominal morning (08:00–10:00), midday (13:00–15:00), and afternoon (17:00–19:00) windows[1].

Data extraction and descriptive statistics

Each numerical decibel value was paired with its adjacent timestamp; non-measurement header and blank cells were excluded. Observations were summarized by site and by the period label assigned in the spreadsheet. Arithmetic mean, sample standard deviation, minimum, maximum, and median were calculated for recorded decibel values. These are descriptive statistics of the workbook entries and must not be interpreted as energy-equivalent LAeq,T without confirmed instrument settings, weighting, sampling interval and calculation method. Repeated readings within a recording session are correlated; they are not independent replicates suitable for simple inferential site comparisons.

Measurement provenance and quality considerations

Environmental noise measurements in Tirana were conducted using the Testo 816-1 sound-level meter and the Noise Capture smartphone application. Both instruments were used during field data collection, and the resulting readings were organized in the supplied workbook. The analysis draws on the combined dataset collected using both instruments, focusing on the recorded sound levels and their spatial and temporal variability rather than instrument-specific comparisons or calibration assessments. Workbook weekday and nominal morning (08:00–10:00), midday (13:00–15:00) and afternoon (17:00–19:00) headings were retained for descriptive grouping. Recorded timestamps were systematically examined to assess consistency with the designated measurement periods. Identified discrepancies were taken into account when interpreting temporal variations, ensuring a consistent and transparent analysis of the dataset. The analysis is observational and exploratory.

Results

Site-level descriptive statistics

The largest arithmetic mean among the selected junctions was recorded at Kamza Terminal (67.54 dB), 2.33 dB above Zogu i Zi (65.21 dB). The largest observed reading, 97.3 dB, occurred in the 21 Dhjetori worksheet, which also had the largest standard deviation (5.72 dB). The differing maximum and average patterns show why one extreme reading should not be substituted for a typical sampled level.

At Zogu i Zi, midday had the largest labelled-period mean (65.93 dB) and afternoon the lowest (64.66 dB). At 21 Dhjetori, the morning mean was 66.23 dB and the afternoon mean 64.54 dB. Kamza Terminal showed a narrow spread between its labelled morning (67.57 dB), midday (67.75 dB) and afternoon (67.31 dB) means. These patterns reflect the recorded sessions only; the sampling windows do not establish continuous exposure between measurements.

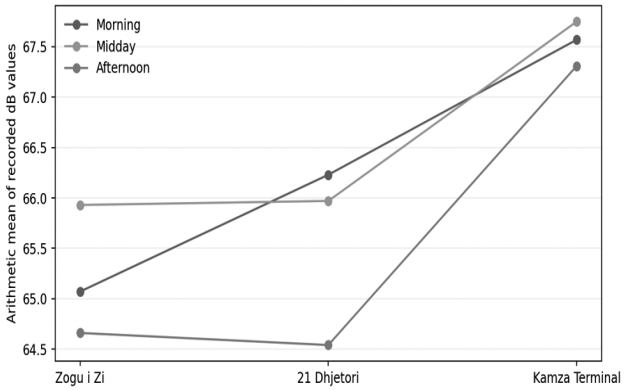


Figure 1. Arithmetic means of recorded dB values by workbook period label and site.

Site	Readings (n)	Mean (dB)	SD	Median	Minimum	Maximum
Zogu i Zi	2,700	65.21	4.22	65.20	47.9	93.5
21 Dhjetori	2,700	65.62	5.72	65.90	47.5	97.3
Kamza Terminal	3,000	67.54	3.32	67.70	37.1	89.9

Table 1. Descriptive statistics calculated from timestamped workbook values; arithmetic dB means are not LAeq.

Labelled time-of-day patterns

Site	Morning: n / mean	Midday: n / mean	Afternoon: n / mean
Zogu i Zi	1,000 / 65.07	850 / 65.93	850 / 64.66
21 Dhjetori	1,000 / 66.23	850 / 65.97	850 / 64.54
Kamza Terminal	1,000 / 67.57	1,000 / 67.75	1,000 / 67.31

Table 2. Number of readings and arithmetic mean (dB) by the workbook's period labels. Some timestamp/label discrepancies require verification.

[1]*The data were collected by students led by MSc student Kelvi Peti.*

Sampling dates and temporal metadata The spreadsheet

Site	Distinct recorded dates	Labelled sessions	Recorded date range
Zogu i Zi	7	15	2024-12-16 to 2025-02-17
21 Dhjetori	7	15	2024-12-16 to 2025-02-17
Kamza Terminal	8	15	2024-12-17 to 2025-02-03

Table 3. Date coverage and number of worksheet-column/date recording groups. The nominal weekday and period headings do not always match time-stamp metadata.

contains repeated readings separated by short intervals within each labelled recording column. Because the duration and instrument response settings are not independently documented, the number of rows should not be interpreted as hours of exposure or as independent monitoring visits. In the Kamza Terminal sheet, at least one column labelled afternoon contains morning timestamps; any strict clock-time analysis requires correction against field logs.

Supplementary neighborhood observations

The additional "Ne lagje" worksheet contains 600 timestamped values recorded on 2025-01-23, with an arithmetic mean of 53.12 dB (SD 5.98; range 43.0–71.0 dB). Because the precise location, acoustic setting, and relationship to the three traffic-junction protocol are not established, these observations are not pooled with the principal 8,400 readings.

Discussion

Interpretation of variability

The expanded workbook confirms that site-level averages in the original manuscript were rounded summaries of much larger sets of recorded values. Kamza Terminal had the highest arithmetic mean but the smallest standard deviation among the three sites; 21 Dhjetori displayed the greatest dispersion and the highest single reading. These distinctions are useful for prioritizing follow-up measurements, but they do not identify a particular traffic source or show that a site has greater long-term population exposure.

Public-health and policy context

Environmental noise is an important public-health and urban environmental concern. The WHO Regional Office for Europe (2018) recommends reducing long-term road-traffic noise exposure below 53 dB Lden and 45 dB Lnight. These health-based recommendations address long-term exposure, while Directive 2002/49/EC establishes a European framework for environmental noise assessment, strategic noise mapping and action planning. Albania has established a national regulatory framework for environmental noise through Law No. 9774 of 12 July 2007, on the Assessment and Management of Environmental Noise, as amended. This framework addresses the assessment, monitoring and management of environmental noise, including noise associated with road transport. It is complemented by secondary legislation establishing monitoring procedures and noise limits for specified environments and activities. The measurements conducted at Zogu i Zi, 21 Dhjetori and Kamza Terminal contribute empirical evidence on environmental noise conditions at three major traffic junctions in Tirana. The recorded mean sound levels, ranging from 65.21 to 67.54 dB, demonstrate differences across the selected locations and provide a basis for identifying priorities for further monitoring. These findings are relevant to the implementation of national environmental noise management measures and to the development of evidence-based urban planning strategies. However, assessing compliance with national limits or WHO recommendations requires the appropriate acoustic indicators, measurement periods and land-use classifications.

Interpretation in relation to the wider literature

The distinction between average conditions and episodic loud events is relevant to environmental noise assessment. Kamza Terminal had the largest arithmetic mean but the lowest site-level standard deviation, whereas 21 Dhjetori had the largest standard deviation and the highest single recorded reading. Such contrasting patterns may reflect differences in the mix of persistent and intermittent sources; however, without source logs or validated time histories, they cannot identify particular vehicles or activities. The findings align with the broader literature in highlighting the need to characterize both temporal variability and longer-term exposure, while remaining restricted to the sampled locations and dates (Basner et al., 2014; WHO, 2018).

Implications for Urban Noise Monitoring

The findings highlight the importance of establishing a systematic and standardized environmental noise monitoring framework in Tirana. Future monitoring should integrate calibrated sound level measurements with traffic volume and composition, vehicle speeds, horn events, meteorological conditions, and precise microphone locations. A consistent sampling protocol covering weekdays, weekends, different times of day, and seasonal variations would enable a more comprehensive assessment of spatial and temporal noise patterns. In accordance with ISO 1996, future studies should incorporate

standardized acoustic indicators, including LAeq,T, Lmax and relevant percentile levels, to support reliable comparisons across monitoring locations and measurement periods.

Implications for Urban Planning and Intervention Evaluation

The results provide an empirical basis for integrating environmental noise considerations into urban planning and traffic management in Tirana. Potential interventions include traffic flow optimization, speed management, improvements to road surfaces and measures to reduce noise exposure near residential areas and other noise-sensitive locations. The selection of appropriate interventions should reflect the specific characteristics and dominant noise sources of each junction. Their effectiveness can be evaluated through comparative measurements conducted before and after implementation under comparable traffic and meteorological conditions. Such an approach would support evidence-based decision-making and contribute to improving the acoustic quality of Tirana's urban environment.

Limitations

The study provides a substantial empirical dataset of 8,400 timestamped noise measurements across three major traffic junctions in Tirana, offering valuable insights into spatial and temporal variations in the urban acoustic environment. The analysis is based on the recorded sound levels and their descriptive statistical characteristics. Differences in sampling periods, measurement dates, and the distribution of observations across locations are considered when interpreting the findings. The available data support a comparative assessment of the selected monitoring locations, while a comprehensive evaluation of long-term environmental noise exposure would require additional measurements, including night-time monitoring, standardized acoustic indicators and complementary traffic and meteorological data. Accordingly, the findings establish a site-specific empirical baseline for future environmental noise research and urban monitoring in Tirana, rather than a citywide exposure assessment.

Conclusions

The comparative analysis identifies Kamza Terminal as the location with the highest average recorded noise level, while 21 Dhjetori exhibited the greatest variability and the highest individual reading. Differences across the designated daytime measurement periods further illustrate the dynamic nature of environmental noise at urban traffic junctions. Together, these findings provide a detailed characterization of the acoustic conditions observed at the three selected locations and contribute valuable empirical evidence to environmental noise research in Tirana.

Beyond documenting existing noise conditions, the study highlights the importance of integrating environmental noise assessment into urban planning, transport management and environmental policy. The findings establish a baseline for systematic monitoring and support the development of targeted measures addressing traffic-related noise in densely used urban areas. Future research incorporating standardized acoustic indicators, extended monitoring periods and complementary traffic data would strengthen the assessment of long-term exposure and enable more comprehensive evaluations of noise-reduction interventions. Overall, the study contributes to a better understanding of urban environmental noise in Tirana and provides a foundation for evidence-based strategies aimed at improving the acoustic quality, environmental sustainability and live ability of the city's urban spaces.

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