ENGINEER

international scientific journal

ISSUE 2, 2025 Vol. 3
E-ISSN
3030-3893
ISSN
3060-5172

SLIB.UZ
Scientific library of Uzbekistan

A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

A bridge between science and innovation

E-ISSN: 3030-3893

ISSN: 3060-5172

VOLUME 3, ISSUE 2

JUNE, 2025

engineer.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

ENGINEER

INTERNATIONAL SCIENTIFIC JOURNAL

VOLUME 3, ISSUE 2 JUNE, 2025

Founder of the international scientific journal "Engineer" – Tashkent State Transport University, 100167, Republic of Uzbekistan, Tashkent, Temiryo'lchilar str., 1, office: 465, e-mail: publication@tstu.uz.

The "Engineer" publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

- Engineering;
- General Engineering;
- Aerospace Engineering;
- Automotive Engineering;
- Civil and Structural Engineering;
- Computational Mechanics;
- Control and Systems Engineering;
- Electrical and Electronic Engineering;
- Industrial and Manufacturing Engineering;
- Mechanical Engineering;
- Mechanics of Materials;
- Safety, Risk, Reliability and Quality;
- Media Technology;
- Building and Construction;
- Architecture.

Tashkent State Transport University had the opportunity to publish the international scientific journal "Engineer" based on the **Certificate No. 1183** of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. **E-ISSN: 3030-3893, ISSN: 3060-5172.** Articles in the journal are published in English language.

Journal Engineer ISSN: 3030-3893 Volume:3| Issue:2| 2025

The impact of traffic intensity and the share of heavy vehicles on air pollution levels on multi-lane urban streets

K.Kh. Azizov[1][a], A.K. Beketov[1][b]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: This study presents the results of field measurements of pollutant concentrations—carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2)—conducted on straight segments of urban streets in Tashkent with varying numbers of lanes (4, 6, and 8 lanes). The measurements were carried out in the spring of 2025 under favorable weather conditions, ensuring consistent data collection across multiple locations. Particular attention was given to the impact of total traffic intensity and the proportion of heavy vehicles (trucks) within the traffic flow. The results indicate a strong positive correlation between both traffic intensity and truck share with pollutant concentrations. As the number of vehicles per hour increases, especially with a higher share of heavy-duty vehicles, the concentrations of pollutants, particularly NO and NO_2, rise significantly—often exceeding national and international air quality standards. CO and SO_2 showed more moderate trends, with exceedances observed mainly under high-intensity and high truck-share conditions. These findings emphasize the disproportionate contribution of heavy vehicles to urban air pollution. The results can serve as a scientific basis for urban environmental planning and the development of traffic management strategies that aim to reduce emissions—such as limiting heavy vehicle access during peak hours or implementing green buffer zones. Overall, the study contributes to a more nuanced understanding of traffic-related emissions in densely populated urban areas and provides evidence for policymakers seeking to balance mobility and environmental sustainability.

Keywords: Urban transport, air pollution, heavy vehicles, traffic intensity, multi-lane streets, gas analyzer, emissions, CO, NO, NO_2, SO_2

1. Introduction

With the increase in motorization in large cities, the problem of air pollution from vehicle emissions is becoming increasingly urgent. One of the main sources of air pollutants in urban environments is vehicles powered by fossil fuels. Their impact is especially significant near heavily used segments of the road network.

Different types of vehicles contribute differently to air pollution. In particular, heavy-duty vehicles typically have higher emission levels compared to passenger cars, which highlights the need to consider their share when assessing environmental impact.

Traffic intensity and the proportion of heavy vehicles significantly influence air pollution levels on multi-lane streets, as shown in various studies [1–7]. Research indicates that high traffic loads from heavy vehicles are more strongly correlated with adverse health effects, such as reduced lung function in children, compared to general traffic volume [1, 2]. Moreover, high-resolution urban air quality modeling shows that traffic-related air pollution is characterized by substantial spatial variability, with higher concentrations near major roads and prevailing wind corridors [3]. Large traffic volumes are associated with increased emissions of nitrogen oxides (NO, NO_2) and particulate matter (PM2.5). Vehicle emissions are a major contributor to deteriorating air quality in cities, especially in densely populated areas such as Beijing [4]. The presence of trucks, especially diesel-powered ones, exacerbates the issue; for instance, a study in Hunts Point, New York, showed that every additional 100 heavy trucks per hour increased elemental carbon concentrations by 1.69 µg/m³ [5]. Emissions of nitrogen oxides (NO, NO_2) and carbon monoxide (CO) are intensified by increased truck traffic, which has been shown to boost NOx emissions while reducing CO levels [6]. Proximity to heavy-duty traffic also increases concentrations of particulate and ultrafine particles, highlighting the health risks associated with intense truck flows [7]. Thus, both traffic intensity and the share of heavy vehicles are critical factors in determining air pollution levels on urban streets.

Previous research has shown that concentrations of pollutants such as carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) depend on traffic intensity. However, most studies have given limited attention to the impact of heavy vehicle share and have insufficiently analyzed differences based on the number of traffic lanes.

This study aims to assess the relationship between concentrations of CO, NO, NO_2, and SO_2 and traffic intensity under varying shares of heavy vehicles on straight urban road segments with different lane counts (4, 6, and 8 lanes). All measurements were conducted in spring under favorable weather conditions on road segments without pavement defects and with high surface evenness. This approach helped to eliminate the influence of microrelief and technical irregularities on emission indicators.

2. Research methodology

The study was conducted on selected urban street segments in Tashkent with different numbers of traffic lanes — 4, 6, and 8 lanes. The streets included: Sarikul Street,

[a] https://orcid.org/0000-0002-5852-4291
[b] https://orcid.org/0000-0003-2075-454X

https://doi.org/10.56143/engineer-tstu.v3i2.66 A bridge between science and innovation
ENGINEER

Eski-Sarikul Street, Beruniy Street, Nurafshon Street, Nukus Street, Amir Temur Avenue, Shakhrisabz Street, Makhtumkuli Street, Alisher Navoi Street, Mukimiy Street, Shota Rustaveli Street, Fargona Yuli Street, and Mirzo Ulugbek Street.

To ensure comparability and accuracy of results, the selection of segments was based on the following criteria:

— The road sections had asphalt concrete surfaces without potholes, cracks, or other defects.

— Each section exhibited excellent surface evenness, verified by visual and instrumental assessments.

— Measurements were carried out in April 2025, during spring under favorable weather conditions (no precipitation, light wind, temperatures between +15 and +25 °C).

— All selected segments were straight, without intersections, traffic lights, or significant terrain variations.

The concentrations of air pollutants — carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) — were measured using a portable gas analyzer (model: Harwest E4000). The device was placed at the roadside at approximately human breathing height (~1.5 m above ground).

For each concentration measurement, the following parameters were also recorded:

— Traffic intensity (vehicles/hour), based on video recordings and manual counts;

— Share of heavy vehicles in the traffic flow (manually classified);

— Average traffic speed (estimated from video and stopwatch timing).

Measurements were conducted during peak morning and daytime hours. Each session lasted at least 2 hours, and average values were calculated from the collected data.

The collected data were grouped by:

— Number of traffic lanes (4, 6, 8);

— Heavy vehicle share intervals: 0–1%, 1–2%, ..., 9–10%;

— Each pollutant type (CO, NO, NO_2, SO_2).

To analyze how concentrations depend on traffic intensity under different shares of heavy vehicles, scatter plots with linear trend lines were constructed. This allowed both visual and quantitative assessment of the relationships.

3. Results and Discussion

Based on the field measurements and data analysis, consistent relationships were established between pollutant concentrations and traffic flow parameters — particularly traffic intensity and the share of heavy vehicles. The results are presented in the form of graphs and tables.

Figure 1 shows the relationship between carbon monoxide (CO) concentration and traffic intensity on road segments with 4, 6, and 8 lanes, under different proportions of heavy vehicles.

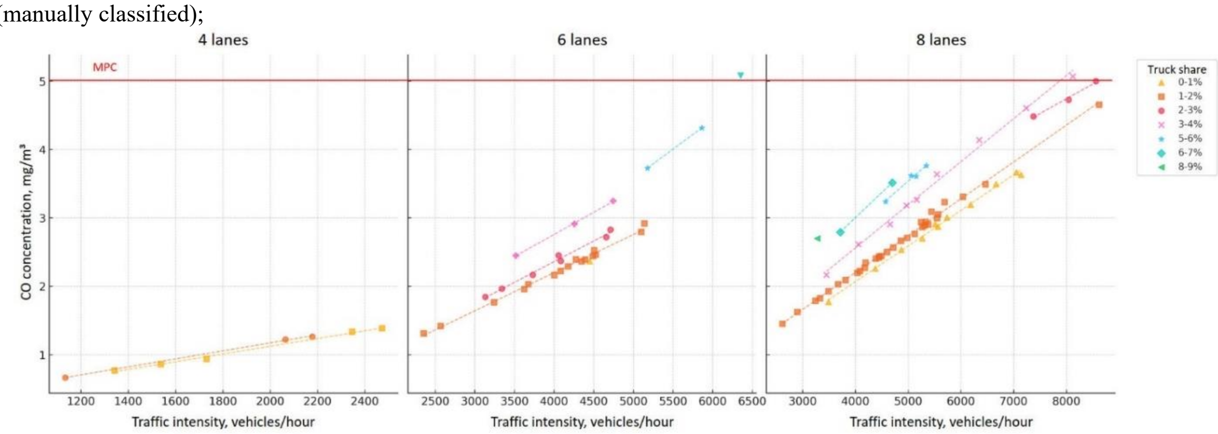

Figure 1. Relationship between CO concentration and traffic intensity

Similar patterns were observed for other pollutants. Figures 2–4 illustrate the trends for NO, NO_2, and SO_2, respectively.

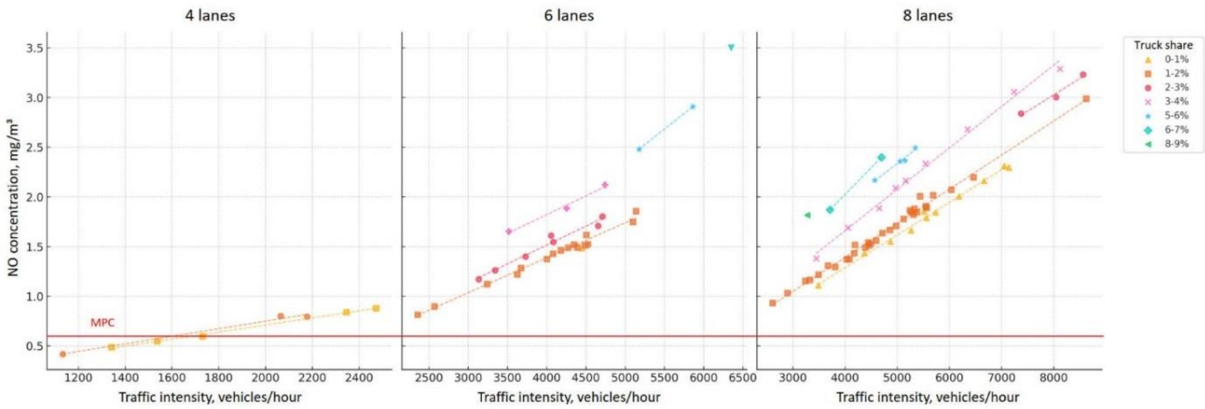

Figure 2. Relationship between NO concentration and traffic intensity

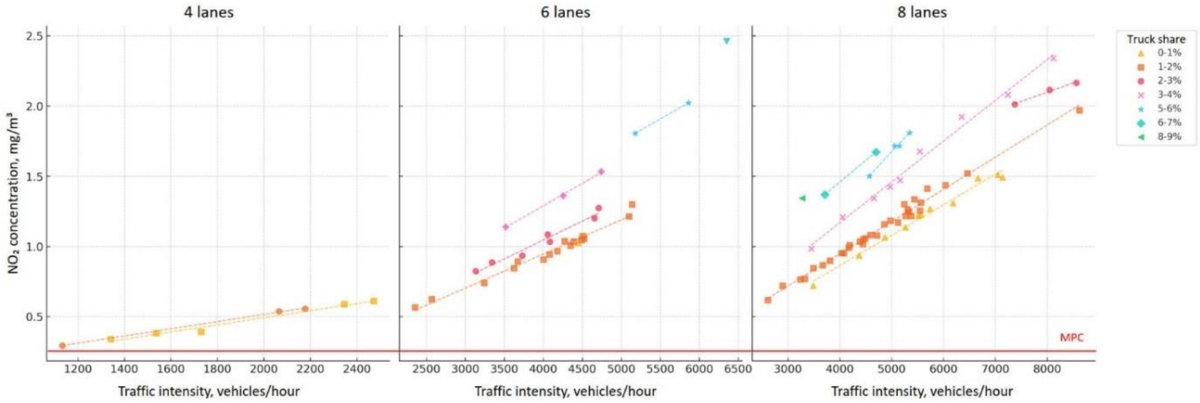

Figure 3. Relationship between NO_2 concentration and traffic intensity

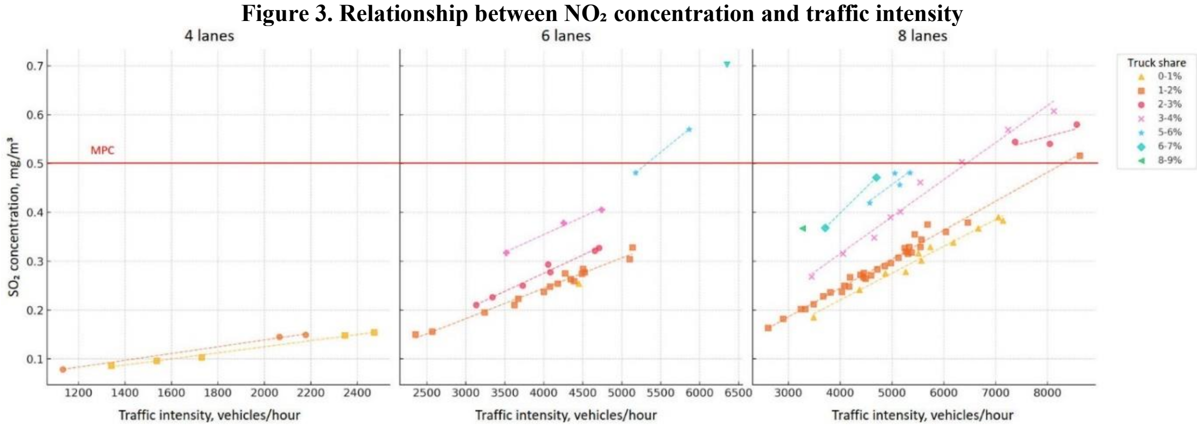

Figure 4. Relationship between SO_2 concentration and traffic intensity

Key Findings:

— An increase in traffic intensity leads to a steady rise in the concentrations of CO, NO, NO_2, and SO_2 across all types of multilane streets.

— CO concentration tends to increase but mostly remains below the maximum permissible concentration (MPC = 5.0 mg/m³). Exceedances are observed mainly on 8-lane streets with high traffic intensity and heavy vehicle share.

The situation with SO_2 (MPC = 0.5 mg/m³) is borderline: exceedances are recorded on certain segments with a high proportion of heavy vehicles and high traffic intensity, especially on 6- and 8-lane roads.

Concentrations of NO and NO_2 exceed their respective MPCs (0.6 and 0.085 mg/m³) in nearly all cases. The levels of exceedance are significant and persistent even under moderate traffic conditions. This indicates that these two components have the most critical environmental impact.

Table 1

Average Concentration Values at Different Truck Shares

Number of lanes	Share of heavy vehicles, %	Avg. traffic intensity, veh/h	CO, mg/m³	NO, mg/m³	NO_2, mg/m³	SO_2, mg/m³
4	1-2	1886	1.056	**0.669**	**0.463**	0.117
4	2-3	1792	1.049	**0.669**	**0.462**	0.124
6	0-1	4449	2.367	**1.484**	**1.024**	0.254
6	1-2	4030	2.214	**1.397**	**0.953**	0.246
6	2-3	3959	2.334	**1.499**	**1.034**	0.272
6	4-5	4173	2.869	**1.885**	**1.344**	0.367
6	5-6	5521	4.022	**2.694**	**1.914**	**0.526**
6	7-8	6351	**5.081**	**3.501**	**2.461**	**0.702**
8	0-1	5623	2.911	**1.819**	**1.215**	0.309
8	1-2	4734	2.595	**1.641**	**1.115**	0.288
8	2-3	7992	4.737	**3.024**	**2.097**	**0.555**
8	3-4	5505	3.508	**2.285**	**1.605**	0.429
8	5-6	5031	3.556	**2.346**	**1.685**	0.459
8	6-7	4205	3.153	**2.133**	**1.050**	0.420
8	8-9	3276	2.699	**1.815**	**1.344**	0.367
etc.	—	—	—	—	—	—

Note: The table presents a sample from a broader dataset; the full dataset includes truck share intervals from 0–1% to 8–9% and traffic intensity from 1000 to 9000 vehicles/hour

The obtained results demonstrate a clear relationship between pollutant concentrations and traffic flow parameters — specifically, traffic intensity and the share of heavy-duty vehicles.

In all cases, concentrations of CO, NO, NO_2, and SO_2 increase with traffic intensity. This confirms a well-known pattern: the more vehicles pass through a road segment per unit time, the higher the volume of emissions. However, this study refines the relationship by considering different street types (4, 6, and 8 lanes) and the composition of the traffic flow, particularly the proportion of heavy vehicles.

The analysis showed that, at the same traffic intensity:

— Pollutant concentrations are significantly higher when the share of heavy vehicles increases;

— NO and NO_2 are the most sensitive to this parameter, with persistent exceedances of permissible limits (MPCs) observed at almost all sites;

— SO_2 and CO concentrations also rise with the share of trucks, but their exceedance levels are less consistent: for CO (MPC = 5.0 mg/m³), exceedances occur only in some cases with both high intensity and a large proportion of trucks; for SO_2 (MPC = 0.5 mg/m³), exceedances are recorded in approximately half of the cases and require further attention.

Heavy-duty vehicles typically have higher specific fuel consumption, which makes their contribution to air pollution disproportionately high, especially when they constitute a large portion of the traffic flow.

Under equal conditions (flow composition and intensity), 8-lane streets exhibit higher average concentrations of pollutants compared to 4- or 6-lane roads.

4. Conclusion

The conducted study established consistent relationships between ambient air pollution levels and traffic flow characteristics on multi-lane urban streets.

Key findings:

1. Pollutant concentrations (CO, NO, NO_2, SO_2) consistently increase with rising traffic intensity, regardless of the number of lanes. This confirms a direct correlation between traffic load and emission levels.
2. The share of heavy-duty vehicles has the most significant impact on pollution levels. At the same traffic intensity, concentrations — especially of NO and NO_2 — are considerably higher in areas with a greater proportion of trucks.
3. 8-lane roads show the highest average pollutant concentrations. This may be attributed to:
   — A higher overall traffic load;
   — A larger share of heavy freight vehicles.

CO concentrations mostly remain below the permissible limit (5.0 mg/m³), whereas NO and NO_2 exceed regulatory thresholds in the vast majority of segments, highlighting their greater environmental and health hazard in urban settings.

References

[1] Azizov K.H. Fundamentals of Traffic Safety Organization: Textbook for Universities. – Tashkent: Fan va Texnologiya, 2012. – 272 p. ISBN 978–9943–10–775–5.

[2] Brunekreef, B., Janssen, N. A., de Hartog, J., Harssema, H., Knape, M., & van Vliet, P. (1997). Air pollution from truck traffic and lung function in children living near motorways. Epidemiology, 8(3), 298-303.

[3] Zhang, Y., Ye, X., Wang, S., He, X., Dong, L., Zhang, N., ... & Xiao, Y. (2021). Large-eddy simulation of traffic-related air pollution at a very high resolution in a mega-city: evaluation against mobile sensors and insights for influencing factors. Atmospheric Chemistry and Physics, 21(4), 2917-2929.

[4] He, J., Wu, L., Mao, H., Liu, H., Jing, B., Yu, Y., ... & Liu, X. (2016). Development of a vehicle emission inventory with high temporal–spatial resolution based on NRT traffic data and its impact on air pollution in Beijing–Part 2: Impact of vehicle emission on urban air quality. Atmospheric Chemistry and Physics, 16(5), 3171-3184.

[5] Lena, T. S., Ochieng, V., Carter, M., Holguín-Veras, J., & Kinney, P. L. (2002). Elemental carbon and PM (2.5) levels in an urban community heavily impacted by truck traffic. Environmental Health Perspectives, 110(10), 1009-1015.

[6] Liu, S., Li, H., Kun, W., Zhang, Z., & Wu, H. (2022). How do transportation influencing factors affect air pollutants from vehicles in China? Evidence from threshold effect. Sustainability, 14(15), 9402.

[7] Weichenthal, S., Van Ryswyk, K., Kulka, R., Sun, L., Wallace, L., & Joseph, L. (2015). In-vehicle exposures to particulate air pollution in Canadian metropolitan areas: the urban transportation exposure study. Environmental science & technology, 49(1), 597-605.

Information about the author

Azizov Kudratulla	Tashkent State Transport University, Candidate in Technical Sciences, Professor of the Department of Construction and Maintenance of Automobile Roads, Email: azizov_q@tstu.uz https://orcid.org/0000-0002-5852-4291
Beketov Amir	Tashkent State Transport University, PhD Student of the Department of Urban Roads and Streets, Email: beketovamir@tstu.uz https://orcid.org/0000-0003-2075-454X

CONTEXT / MUNDARIJA