ENGINEER

international scientific journal

ISSUE 2, 2025 Vol. 3

E-ISSN
3030-3893

ISSN
3060-5172

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TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
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ENGINEER

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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.

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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.

Analysis of the impact of speed and lane distribution on pollutant concentrations in the urban street environment

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

Abstract: This article presents the results of an in-depth analysis of the relationship between lane-specific traffic characteristics—namely, lane position and average vehicle speed—and the concentration levels of major air pollutants (CO, NO, NO_2, SO_2) in an urban environment. Field measurements were conducted in spring 2025 on straight, well-maintained segments of urban streets in Tashkent with different lane configurations (4, 6, and 8 lanes), under favorable meteorological conditions. The study examined how the position of traffic lanes (from right-most to left-most) and their corresponding average speeds affect pollutant levels. The data revealed a consistent trend: pollutant concentrations are highest on the first (right-most) lane, where average speeds are lowest, and gradually decrease toward the center and left-most lanes, where speeds are higher and traffic flow is more stable. This pattern was particularly evident for NO and NO_2, with frequent exceedances of the maximum permissible concentrations, while CO and SO_2 remained within acceptable limits in most cases. The findings underscore the role of stop-and-go traffic, common in right-hand lanes (due to loading, unloading, and public transport), in intensifying localized air pollution. These results highlight the importance of integrating lane-specific traffic flow characteristics into urban planning and traffic management policies. Recommendations include reducing heavy vehicle traffic in right-hand lanes during daytime hours and enhancing traffic flow efficiency to mitigate pollutant buildup in high-exposure zones. This study provides a practical foundation for improving air quality through street design and targeted transport regulations.

Keywords: Vehicle speed, traffic lanes, air pollution, urban transport, emissions, CO, NO, NO_2, SO_2, Tashkent, gas analyzer

1. Introduction

In conditions of high traffic volume and dense urban development, air pollution caused by vehicle emissions remains one of the most pressing environmental issues for large cities. A significant portion of pollutants—such as carbon monoxide (CO), nitrogen oxides (NO, NO_2), and sulfur dioxide (SO_2)—is released into the atmosphere at street level, where humans directly interact with their environment.

Various studies have shown that vehicle speed and lane distribution significantly affect pollutant concentrations in ambient air. Traffic dynamics, including vehicle speed and lane usage, directly influence emissions of major pollutants such as nitrogen oxides (NO, NO_2) and particulate matter (PM2.5) into the urban environment [1, 2]. For example, increased vehicle speed can lead to higher emissions due to greater fuel consumption, while lane distribution impacts traffic flow and congestion, which further affects pollutant levels [3, 4]. Meteorological conditions—such as wind speed and direction—also influence the dispersion of pollutants, potentially increasing or decreasing concentrations downwind of traffic sources [1, 5]. Moreover, studies show that specific traffic-related micropollutants, including polycyclic aromatic hydrocarbons (PAHs), tend to accumulate in areas with heavy traffic, highlighting the role of lane distribution in pollutant dynamics [6]. Understanding these interrelations is crucial for effective air quality management and urban planning.

Thus, not only the traffic volume and vehicle composition but also lane distribution and travel speed play a significant role in determining pollutant concentrations. Edge lanes (especially the first, right-hand lane) often feature slower-moving traffic, frequent stops and starts, and a higher proportion of heavy and public transport vehicles. In contrast, central and left-hand lanes typically provide higher and more stable travel speeds.

Given this, the present study focuses on assessing the impact of vehicle speed and lane distribution on pollutant concentrations along straight segments of urban streets with varying numbers of lanes (4, 6, and 8). All measurements were conducted under favorable weather conditions in spring 2025, on road sections without pavement defects, allowing the exclusion of confounding factors and emphasizing traffic structure analysis.

2. Research methodology

The study was conducted in the city of Tashkent on flat, straight segments of urban roads with varying numbers of traffic lanes (4, 6, and 8 lanes), including the following streets: Sarikul Street, 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

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

Street, and Mirzo Ulugbek Street. All segments were selected according to the following criteria:

— absence of pavement defects (potholes, cracks, deformations);

— high surface smoothness, ensuring stable traffic flow;

— no intersections, public transport stops, or traffic lights within the segment;

— favorable weather conditions: temperature between +15 °C and +25 °C, light wind, no precipitation;

— measurement period: April 2025 (spring).

These conditions were intended to create standardized settings for comparing pollutant concentrations across different traffic lanes.

Measurements were conducted individually for each lane, accounting for average speed and lane position:

— 1st lane (rightmost) — typically the most congested, with the lowest average speed;

— 2nd lane — higher average speed;

— 3rd and 4th lanes — highest speed, with fewer stops and interruptions.

— For each lane, the following were recorded:

— concentrations of pollutants (CO, NO, NO_2, SO_2) using a portable gas analyzer (Harwest E4000 model);

— average speed of traffic — determined via video recordings and stopwatch timing;

— time of day and observation duration (measurements were conducted primarily during peak hours: morning and daytime).

The collected data were grouped by street type (4, 6, or 8 lanes), lane number, and pollutant type. Graphs were created to show the relationship between pollutant concentration and average speed for each lane. Linear trend lines were applied for both visual and quantitative analysis.

This approach allowed for the identification of how air pollution levels vary within a single traffic stream depending on vehicle speed and lane position.

3. Results and Discussion

The analysis results showed that pollutant concentrations depend not only on the overall traffic intensity but also on the lane position and the average vehicle speed within each lane. In all cases, a clear trend was observed: as the average speed decreases (i.e., closer to the rightmost, first lane), the concentrations of pollutants increase.

Figure 1 presents the graphs of CO concentration versus average speed by lane for streets with 4, 6, and 8 lanes. The following patterns were identified:

— the 1st lane shows the highest CO levels at the lowest speeds (25–40 km/h);

— the 2nd lane shows intermediate values;

— the 3rd and 4th lanes show the lowest concentrations at the highest speeds (45–60 km/h).

Despite the increase in CO concentrations in the right lanes, in most cases the values remain below the Maximum Permissible Concentration (MPC) threshold of 5.0 mg/m³. This can be explained by more efficient fuel combustion under moderate loads and relatively high traffic speeds.

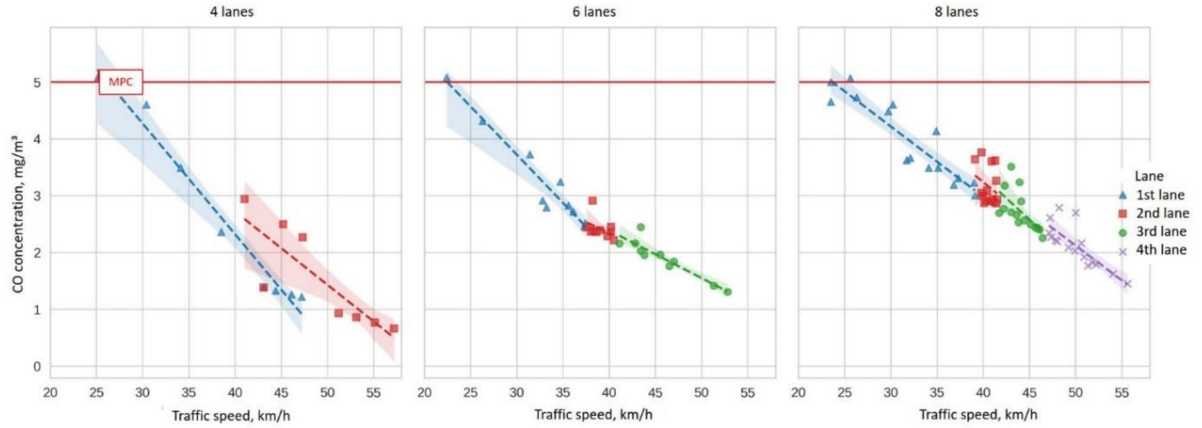

Figure 1. CO concentration vs. speed by lane

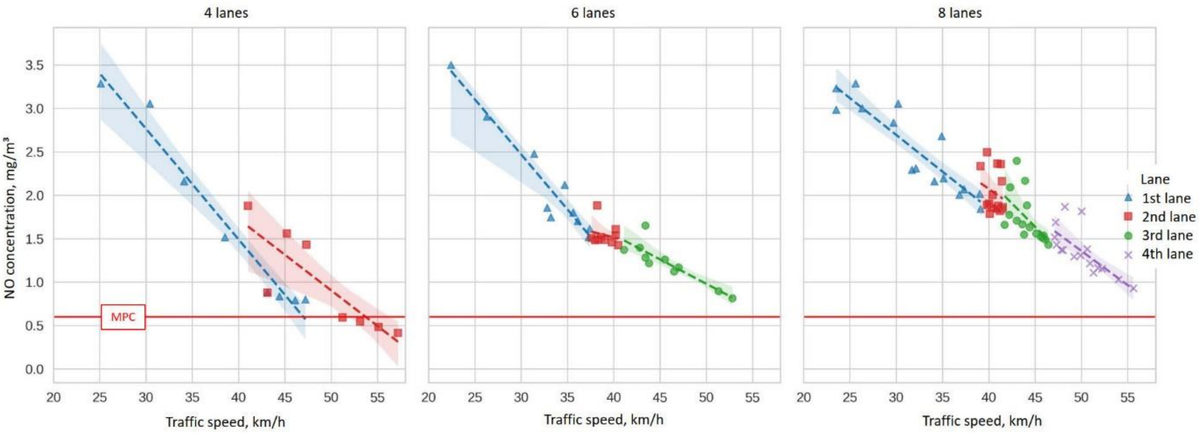

Figure 2. NO concentration vs. speed by lane

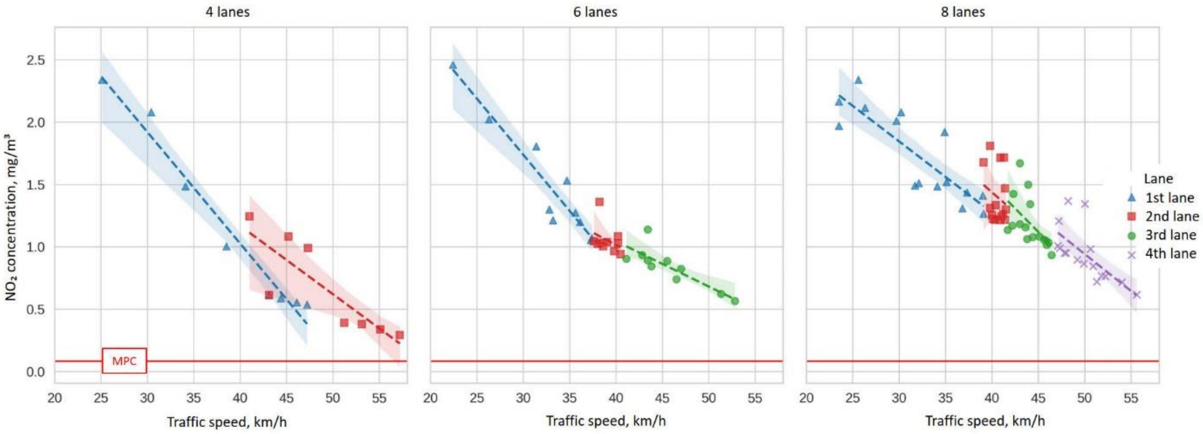

Figure 3. NO_2 concentration vs. speed by lane

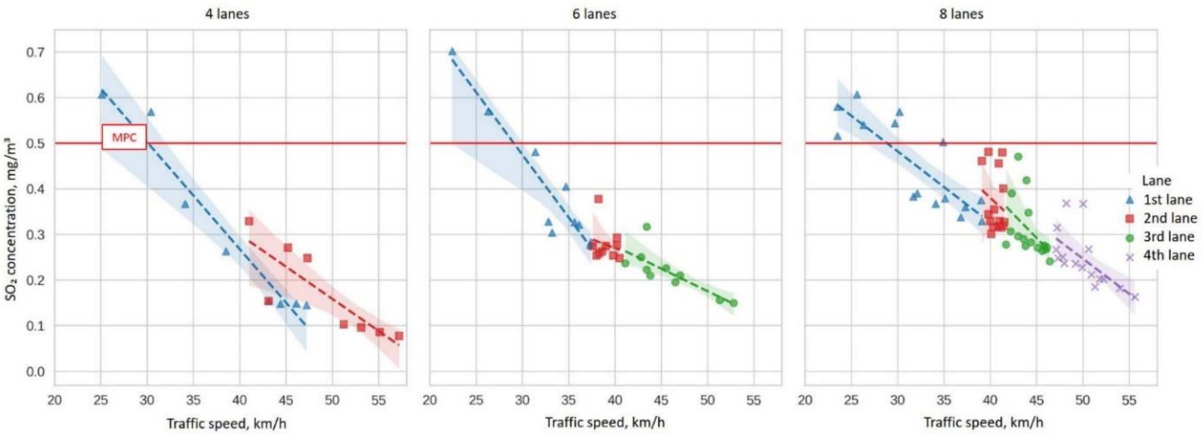

Figure 4. SO_2 concentration vs. speed by lane

Figures 2–4 present similar trends for NO, NO_2, and SO_2. Key observations include:

— NO and NO_2 show significant and consistent MPC exceedances across nearly all segments, especially in right lanes at low speeds. For NO, the threshold of 0.6 mg/m³ is regularly exceeded on all street types. NO_2, with an MPC of 0.085 mg/m³, exceeds the limit in most observations, indicating its high toxicity even at moderate emission levels.

For SO_2, the situation is more variable: exceedances occur mainly on the 1st lane segments, especially when the share of heavy vehicles is high. In contrast, concentrations on the left lanes generally remain within acceptable limits. Thus, SO_2 shows a roughly 50/50 pattern — exceedances in about half the cases, compliance in the other half.

Table 1

Average Pollutant Concentrations by Lane and Street Type

Number of lanes	Lane Number	Speed, km/h	CO, mg/m³	NO, mg/m³	NO_2, mg/m³	SO_2, mg/m³
4	1	45.2	1.301	**0.828**	**0.574**	0.149
4	2	54.2	0.807	0.510	**0.351**	0.091
6	1	32.7	3.130	**2.126**	**1.380**	0.400
6	2	39.0	2.940	**1.542**	**1.053**	0.277
6	3	45.8	1.570	**1.219**	**0.836**	0.217
8	1	31.9	3.940	**2.532**	**1.735**	0.452
8	2	40.6	3.156	**2.027**	**1.398**	0.369
8	3	44.2	2.702	**1.725**	**1.181**	0.309
8	4	50.1	2.113	**1.353**	**0.938**	0.246
etc.	—	—	—	—	—	—

Note: The table presents average values per lane. The complete dataset includes over 20 combinations of lanes and speeds.

The results confirm a significant influence of lane position and average traffic speed on urban air pollution levels.

The analysis showed that the 1st (rightmost) lane on streets with 4, 6, and 8 lanes consistently exhibited the highest pollutant concentrations. Several factors may contribute to this:

— lower average speeds on the right lane;

— more frequent braking, stop/start cycles, lane changes, and maneuvers;

— dominance of heavy-duty and public transport vehicles in this lane, which contribute disproportionately to emissions.

As the average lane speed increases (from right to left), a consistent decline in pollutant concentrations is observed. This confirms that:

— low speeds and non-uniform traffic contribute to higher emissions;

— higher speeds in central and left lanes (2nd, 3rd, and 4th) are associated with lower pollution levels under otherwise equal conditions.

The differences are especially pronounced on 8-lane streets, where, for example, the CO concentration difference between the 1st and 3rd lanes can reach 0.45 mg/m³. This may be due to:

— higher overall traffic density and complex traffic structures;

— a greater volume of vehicles, including heavy trucks;

limited dispersion of pollutants due to dense urban development (the “urban canyon” effect).

4. Conclusion

The analysis revealed that concentrations of air pollutants (CO, NO, NO_2, SO_2) are highest in the first (rightmost) traffic lane, regardless of the total number of lanes on the street.

Key findings:

1. The average vehicle speed is inversely proportional to pollution levels: when speed decreases from 55–60 km/h to 25–30 km/h, pollutant concentrations increase by 1.5 to 2 times.

Central and left lanes (2nd, 3rd, and 4th) provide more favorable conditions for reducing emissions due to more stable speeds and fewer stops.

References

[1] Li, L., Wu, J., Hudda, N., Sioutas, C., Fruin, S. A., & Delfino, R. J. (2013). Modeling the concentrations of on-road air pollutants in southern California. Environmental science & technology, 47(16), 9291-9299.

[2] Zhang, S., Wu, Y., Huang, R., Wang, J., Yan, H., Zheng, Y., & Hao, J. (2016). High-resolution simulation of link-level vehicle emissions and concentrations for air pollutants in a traffic-populated eastern Asian city. Atmospheric Chemistry and Physics, 16(15), 9965-9981.

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

[5] Coria, J., Bonilla, J., Grundström, M., & Pleijel, H. (2015). Air pollution dynamics and the need for temporally differentiated road pricing. Transportation Research Part A: Policy and Practice, 75, 178-195.

[6] Gasperi, J., Le Roux, J., Deshayes, S., Ayrault, S., Bordier, L., Boudahmane, L., ... & Gromaire, M. C. (2022). Micropollutants in urban runoff from traffic areas: target and non-target screening on four contrasted sites. Water, 14(3), 394.

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

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