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AIR POLLUTION LEVELS, MAJOR SOURCES, AND MITIGATION STRATEGIES

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Abstract. This study examines the level of atmospheric air pollution in the conditions of Tashkent city and Kashkadarya region, with particular emphasis on the key anthropogenic factors contributing to its formation. The concentrations of major air pollutants, including particulate matter (PM2.5), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), were evaluated over the period 2023–2026.

The findings indicate that Tashkent exhibits elevated levels of PM2.5 and NO_2, primarily associated with increased traffic density and rapid urbanization processes. In contrast, higher SO_2 concentrations observed in the Kashkadarya region are largely attributed to industrial activities and fuel-energy sector emissions.

Furthermore, the study proposes scientifically grounded measures aimed at improving air quality and enhancing environmental protection.

Key words:atmospheric air, PM2.5, NO_2, SO_2, air pollution, environmental safety, monitoring

Introduction. Clean atmospheric air is a fundamental prerequisite for public health, environmental sustainability, and stable economic development. In recent years, the level of air pollution has been steadily increasing worldwide due to rapid industrialization, expansion of transport infrastructure, and intensive use of energy resources. Air emissions typically include fine particulate matter (PM2.5 and PM10), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), and various volatile organic compounds. Elevated concentrations of these pollutants in the atmosphere can have adverse effects on human health, contributing to respiratory diseases, allergic conditions, and a range of other environmental and health-related problems

In the Central Asian region, particularly in the Republic of Uzbekistan, atmospheric air pollution remains one of the most pressing environmental challenges. Accelerated urbanization, industrial activities, increased consumption of fuel and energy resources, and the rapid growth in the number of vehicles are among the key factors influencing air quality. In this context, continuous monitoring and systematic assessment of air pollution levels, especially in large urban centers and industrial zones, have become essential scientific and practical tasks.

Tashkent, as the largest administrative and economic center of the country, is characterized by a high degree of urbanization and intensive traffic flow. Consequently, vehicular emissions, construction activities, and both domestic and industrial sources play a significant role in shaping the city's air pollution profile. In contrast, the Kashkadarya region represents one of the major oil and gas and energy-producing areas of Uzbekistan. Industrial enterprises, gas processing complexes, and fuel-energy facilities located in this region exert a considerable impact on ambient air quality.

From this perspective, a comprehensive analysis of air pollution levels in Tashkent and the Kashkadarya region, identification of major pollution sources, and the development of effective mitigation measures are of significant scientific and practical importance. The objective of this study is to assess the level of atmospheric air pollution in these regions, analyze its primary sources, and propose scientifically grounded strategies aimed at improving air quality and ensuring environmental safety.

Concentrations of major atmospheric pollutants in Tashkent city and the Kashkadarya region over the period 2023–2026.

Table 1

Year	Region	PM2.5 (μg/m³)	NO_2 (μg/m³)	SO_2 (μg/m³)	CO (mg/m³)
2023	Tashkent city	32	41	9	1.3
2023	Kashkadarya region	26	29	12	1.1
2024	Tashkent city	34	44	10	1.4
2024	Kashkadarya region	27	31	13	1.2
2025	Tashkent city	36	46	10	1.5
2025	Kashkadarya region	28	32	14	1.3
2026	Tashkent city	35	45	9	1.4
2026	Kashkadarya region	29	33	14	1.3
2023	Tashkent city	32	41	9	1.3

The quantitative analysis of the data presented in Table 1 reveals clear spatial and temporal patterns in atmospheric pollutant concentrations between Tashkent city and the Kashkadarya region over the period 2023–2026.

First, PM2.5 concentrations in Tashkent show a steady increase from 32 μg/m³ in 2023 to a peak of 36 μg/m³ in 2025, followed by a slight decrease to 35 μg/m³ in 2026. In contrast, the Kashkadarya region demonstrates lower but gradually increasing values, rising from 26 μg/m³ to 29 μg/m³ over the same period. On average, PM2.5 levels in Tashkent are approximately 25–30% higher than in Kashkadarya, indicating a significantly stronger impact of urban emission sources.

A similar trend is observed for NO_2 concentrations. In Tashkent, NO_2 levels increase from 41 μg/m³ in 2023 to 46 μg/m³ in 2025, before slightly decreasing to 45 μg/m³ in 2026. In the Kashkadarya region, NO_2 concentrations remain consistently lower, ranging from 29 to 33 μg/m³. The relative difference between the two regions reaches approximately 35–40%, highlighting the dominant role of transport-related emissions in urban environments.

In contrast, SO_2 concentrations exhibit an opposite pattern. The Kashkadarya region shows higher SO_2 levels, increasing from 12 μg/m³ in 2023 to 14 μg/m³ in 2025–2026, whereas Tashkent maintains lower values in the range of 9–10 μg/m³. This indicates that industrial and fuel-energy sector emissions are the primary contributors to sulfur dioxide pollution in the region.

Carbon monoxide (CO) concentrations also follow distinct trends. In Tashkent, CO levels rise from 1.3 mg/m³ in 2023 to 1.5 mg/m³ in 2025, followed by a slight decrease in 2026. Meanwhile, in the Kashkadarya region, CO concentrations remain relatively stable, fluctuating between 1.1 and 1.3 mg/m³. This again reflects the stronger influence of traffic emissions in urban areas.

Overall, the data demonstrate that Tashkent is characterized by higher concentrations of PM2.5, NO_2, and CO, while the Kashkadarya region is more affected by SO_2 pollution. These differences clearly indicate the contrasting nature of emission sources: transport and urban activities dominate in Tashkent, whereas industrial and energy-related sources prevail in Kashkadarya.

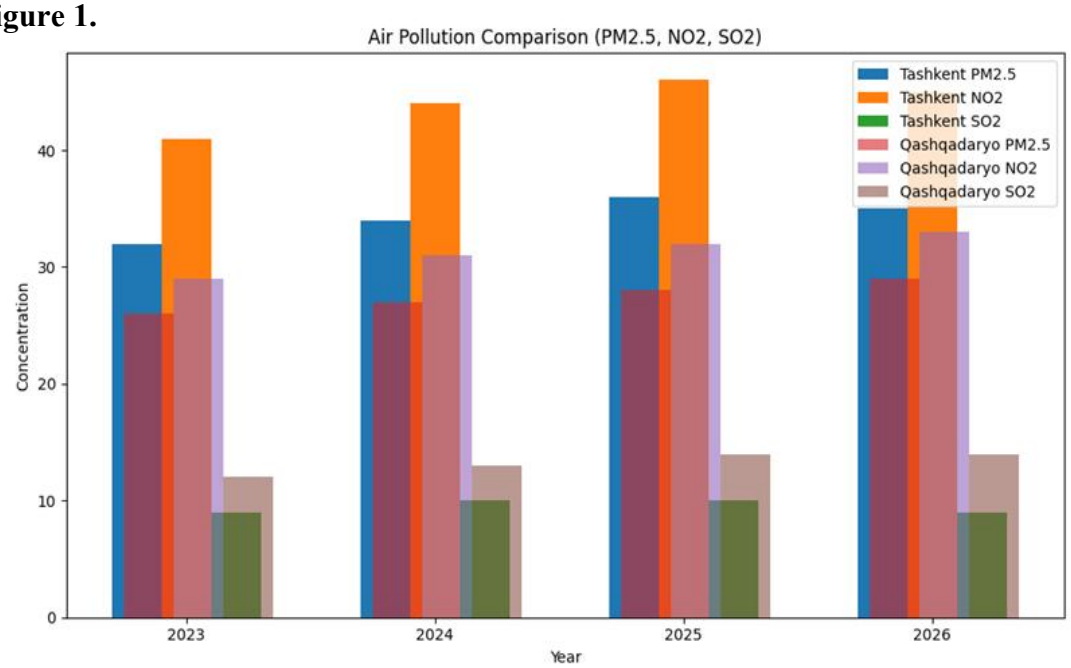
Furthermore, the temporal dynamics suggest a general upward trend in pollutant concentrations until 2025, followed by partial stabilization or slight reduction in 2026. This may reflect the initial effects of environmental regulation measures or changes in emission control practices.

The results confirm that air pollution patterns are strongly dependent on regional economic structure, energy consumption profiles, and the intensity of anthropogenic activities. Therefore, effective air quality management requires region-specific strategies that target the dominant emission sources in each area.

According to the analysis of Figure 1, a consistent upward trend is observed across all indicators in Tashkent. The increase in PM2.5 and NO_2 concentrations reflects the growing impact of transport emissions and industrial activities. In contrast, SO_2 levels show an increasing trend until 2025, followed by a slight decline in 2026.

A similar upward tendency is observed in the Kashkadarya region; however, pollutant levels remain lower compared to Tashkent. This can be explained by the relatively lower intensity of anthropogenic pressure in the region.

Temporal variation of atmospheric pollutant concentrations
Figure 1.



Overall, air pollution levels are higher in Tashkent, primarily due to urbanization and increased transport load. The findings indicate the necessity of strengthening measures aimed at protecting atmospheric air quality.

Furthermore, during the period 2023–2026, air pollution indicators demonstrate a general increasing trend, which may be associated with the expansion of industrial production and the growth of vehicular traffic.

Conclusion

The conducted study revealed that the level of atmospheric air pollution in Tashkent city and the Kashkadarya region is predominantly shaped by anthropogenic factors. Monitoring data for 2023–2026 indicate that regional differences in air quality are directly linked to economic activity, transport intensity, and the spatial distribution of industrial sectors.

The results confirm that PM2.5 and NO_2 concentrations are dominant in Tashkent, whereas relatively higher SO_2 levels are characteristic of the Kashkadarya region. This reflects differences in the structure of anthropogenic impacts across the studied areas.

The findings highlight the need for an integrated approach to air quality management. Key priority areas include reducing transport emissions, modernizing industrial emission control technologies, and digitalizing environmental monitoring systems.

The results of this study can serve as a scientific basis for improving regional environmental policies and ensuring sustainable environmental conditions.

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