SPATIOTEMPORAL ANALYSIS OF CO EMISSIONS IN TASHKENT CITY (1994–2023) USING GIS TECHNOLOGIES

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https://doi.org/10.5281/zenodo.17941525

ARTICLE INFO

Received: 11th December 2025
Accepted: 12th December 2025
Online: 13th December 2025

KEYWORDS

Tashkent city, air pollution, carbon monoxide (CO), GIS

ABSTRACT

This study investigates the changes in concentrations of key air pollutants - carbon monoxide (CO) - in Tashkent city over a 30-year period from 1994 to 2023 in summer. The aim of the research is to analyze quantitative trends in these pollutants, generate spatial distribution maps, and identify the primary sources of air contamination. Data were collected from 12 observation stations operated by the Hydrometeorological Service of the Republic of Uzbekistan. Spatial analysis was conducted using GIS technologies, particularly the Inverse Distance Weighting (IDW) interpolation method in ArcGIS Pro. Seasonal maps were created at five-year intervals. Additionally, graphical analysis and descriptive statistical methods were used to assess the trends in pollutant concentrations. Results indicate that concentrations of CO peaked between 1994 and 2003, followed by a significant decline starting in 2008. This research provides a scientific foundation for air quality monitoring and environmental safety initiatives in Tashkent city.

Introduction

Nowadays, air pollution in urban areas has become an increasingly urgent environmental issue. The acceleration of urbanization, the rise in the number of vehicles, the expansion of industrial enterprises, and the increase in energy consumption have resulted in the excessive emission of pollutants such as CO_2, CO, SO_2, NO_x, O_3, $PM_{2.5}$, and PM_{10} into the atmosphere [1,2,3].

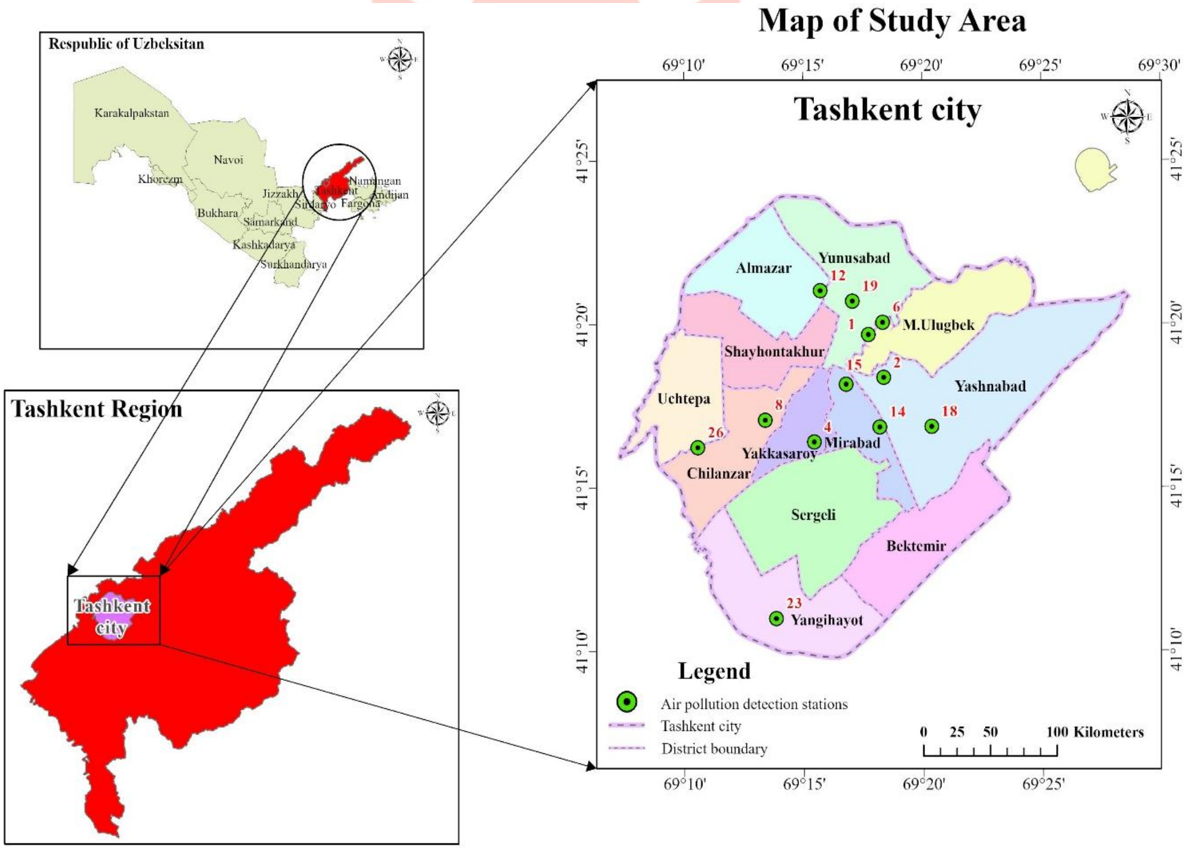
Tashkent, the political, economic, and cultural capital of the Republic of Uzbekistan and the city with the highest degree of urbanization, has experienced notable demographic and economic growth in recent years. As a result, the expansion of the energy, transportation, and industrial sectors has contributed to the emission of various harmful gases into the atmosphere, including CO, NO_2, SO_2, CO_2, particulate matter (PM), and aerosols. Furthermore, Tashkent's geographic location - situated on a foothill plain - and its climatic conditions, characterized by a sharply continental climate, low precipitation, and prevailing winds, lead to prolonged atmospheric residence of pollutants instead of their natural filtration. Consequently, the horizontal and vertical diffusion of pollutants is reduced, photochemical reactions and temperature inversion phenomena are intensified, resulting in increasing air pollution.

The primary objective of this research is to determine the dynamic changes in the concentrations of the gases most influencing air pollution in Tashkent city - carbon monoxide (CO) - over the period from 1994 to 2023 in summer. Based on the obtained results, seasonal distribution maps will be created, and the sources affecting the concentrations of CO in the air will be identified.

This study focuses on the emissions of carbon monoxide (CO) in Tashkent from 1994 to 2023. This gas, when increased in atmospheric concentration, significantly contribute to climate change, deterioration of human health, and adverse environmental impacts [4,5,6,7].

Fig.1. Study area and air pollution monitoring stations

Source: own study.



Main part

Tashkent city is the capital of Uzbekistan and serves as the political and cultural center of the country. The city is situated on a wide piedmont plain of the Western Tien Shan mountains. Tashkent covers an area of 410 square kilometers and is divided into 12 administrative districts. As of January 1, 2025, the permanent population of Tashkent was approximately 3,112,800 people. The climate of Tashkent is characterized by hot and dry summers and relatively mild and unstable winters. The hottest month is July, with an average temperature ranging from +24°C to +27°C and maximum temperatures reaching +43°C to +44°C. The coldest month is January, with an average temperature of 0,6°C. The annual average precipitation is approximately 400 mm. The average annual relative humidity is around 58%, with January humidity levels between 60 % and 70 %, and dropping below 30 % in July.

This study investigates the spatial and temporal variations of carbon monoxide (CO) emissions in the atmosphere of Tashkent city over a 30-year period from 1994 to 2023 in summer. The research methodology comprises several stages: data collection, preliminary data processing, spatial analysis using Geographic Information Systems (GIS), map creation through the application of the Inverse Distance Weighting (IDW) interpolation method, and statistical data processing. To assess the air pollution status in Tashkent city, data on the amounts of carbon monoxide (CO) emitted into the atmosphere from 1994 to 2023 were obtained from the archives of the Hydrometeorological Service Agency under the Ministry of Ecology, Environmental Protection, and Climate Change of the Republic of Uzbekistan. To visualize the spatial distribution of CO across the city, the Inverse Distance Weighting (IDW) interpolation method was applied. IDW is a deterministic technique widely used in environmental research to estimate values at locations where measurements are not available, based on the values recorded at surrounding points. The interpolation algorithm objective is to use measurements $z\ (s_i),\ i= 1,2,\ldots,\ n$, set in points locations, to create an probability of the point value of the experimented property in the location s0 when the observations are not existing. The weights given to elements are a function of the distance of the element from the estimate location. The weights are typically acquired through the inverse squared distance (signified by the exponent -2), and the estimate function of interpolation can be set as:

$$\hat{z}(s_0) = \frac{\sum_{i=1}^{n} z(s_i) d_{i0}^{-2}}{\sum_{i=1}^{n} d_{i0}^{-2}} \qquad (1)$$

where d_{i0} is the distance by which the s_0 and the s_i are detached [3].

Seasonal variations of carbon monoxide (CO) in urban air from 1994 to 2023

In summer, 1994 also exhibited the highest CO values among all studied years. In 1994, levels across most of the city exceeded 3000 μg/m^3. This decreased by 2008, when summer concentrations averaged between 2200 and 2300 μg/m^3. A consistent downward trend was observed after 2013. The highest summer CO levels during the study period were recorded between 1998 and 2003. By 2023, average summer concentrations in the northern, western, and southern parts of the city ranged from 1600 to 2000 μg/m^3.

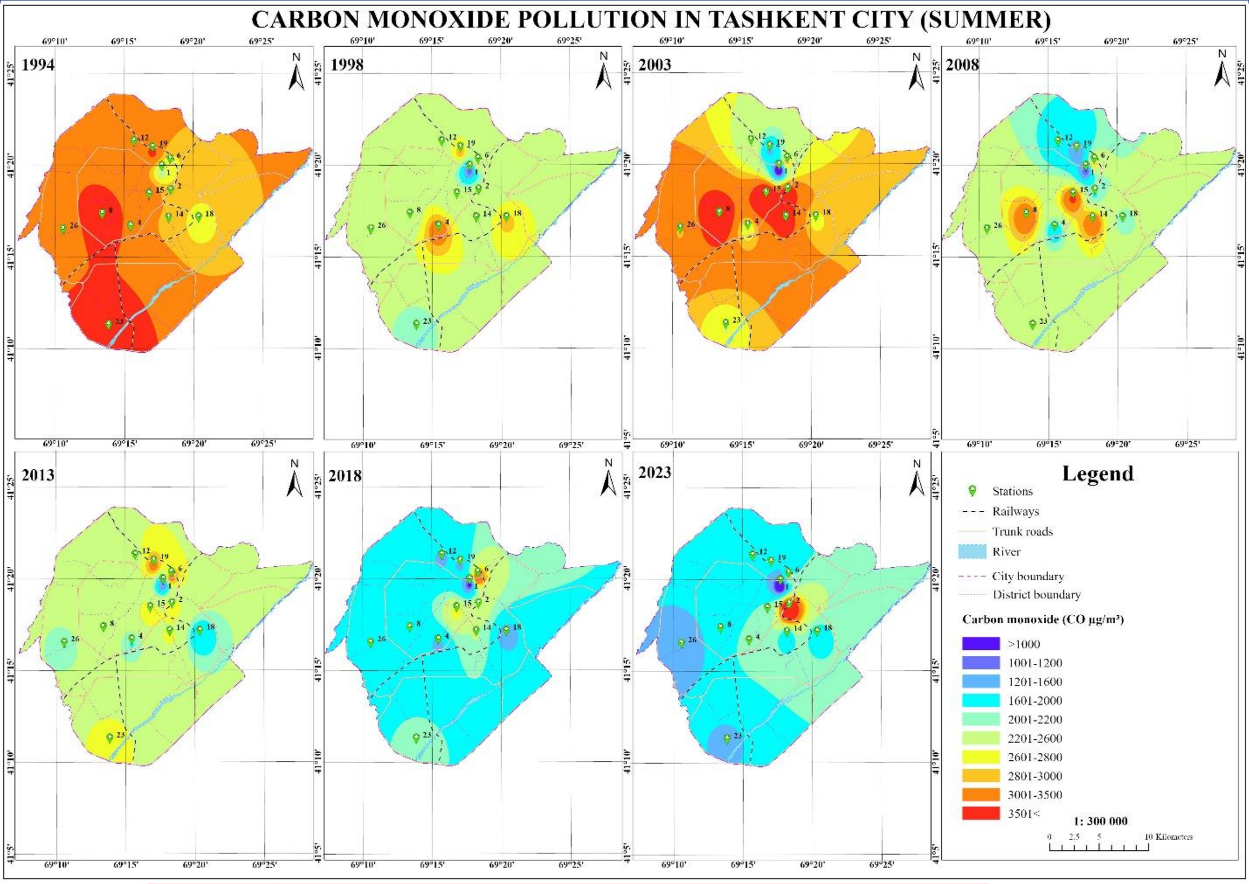


Fig.2. Seasonal variation in CO emissions into the air in Tashkent city during summer between 1994 and 2008

Source: own study.

Conclusion

This study analyzed the seasonal dynamics of carbon monoxide (CO) emissions in the air of Tashkent city over the period from 1994 to 2023. The results indicate that although the amounts of these gases released into the atmosphere have decreased compared to 1994, a recent upward trend has been observed. During the study period, the highest emission levels for CO pollutants were recorded in 2003. Seasonal analysis revealed that CO concentrations peaked during the summer. This pattern is primarily attributed to the increased use of fuel oil and other heating fuels during the cold season. The analysis demonstrated that industrial activity, construction, and the transport sector in Tashkent play significant roles in the emission of air pollutants.

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