UN environment programme

Air Quality in Termez, Uzbekistan

Assessment of Key Emission Sources and Recommendations for Enhancing Air Quality Monitoring and Management

Executive Summary



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MINISTRY OF ECOLOGY, ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE OF THE REPUBLIC OF UZBEKISTAN

2025

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Original English version: *Air Quality in Termez, Uzbekistan: Assessment of Key Emission Sources and Recommendations for Enhancing Air Quality Monitoring and Management.*

ISBN: 978-92-807-4243-5

Job number: ROE/2725/TA

DOI: http://doi.org/10.59117/20.500.11822/48984

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Suggested citation:
United Nations Environment Programme (2025). *Air Quality in Termez, Uzbekistan: Assessment of Key Emission Sources and Recommendations for Enhancing Air Quality Monitoring and Management.* Tashkent. https://wedocs.unep.org/handle/20.500.11822/49064

Production: Tashkent

URL: https://www.unep.org/resources/report/air-quality-termez-uzbekistan-assessment-key-emission-sources-and-recommendations

Cover design: Nigina Sodikova

Co-produced with:

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The report provides the first comprehensive scientific assessment of air quality in Termez to support evidence-based policymaking and air quality management. It is based on a detailed analysis of hourly monitoring data from the automatic air quality station located in central Termez (covering the period from May 2023 to December 2024), meteorological observations, satellite retrievals, and local emission inventories. Developed by UNEP and Finnish Meteorological Institute at the request of the Ministry of Ecology, Environmental Protection and Climate Change of Uzbekistan, and in collaboration with local consultants, the report aims to identify pollution sources and priority interventions to improve air quality and protect public health in Termez.

This report provides a solid scientific and technical foundation for strengthening local and national action on air quality. The findings confirm that particulate pollution in Termez is driven by both natural and anthropogenic factors, highlighting clear opportunities for targeted and evidence-based interventions. Implementing the recommended measures can significantly reduce air pollution and its health burden. Ensuring high data quality, improving the accuracy of emission inventories, and replicating and scaling up effective interventions across Uzbekistan will be essential for achieving long-term and sustainable improvements in air quality.



Arid landscapes around Termez area are highly vulnerable to wind erosion and sand and dust storms
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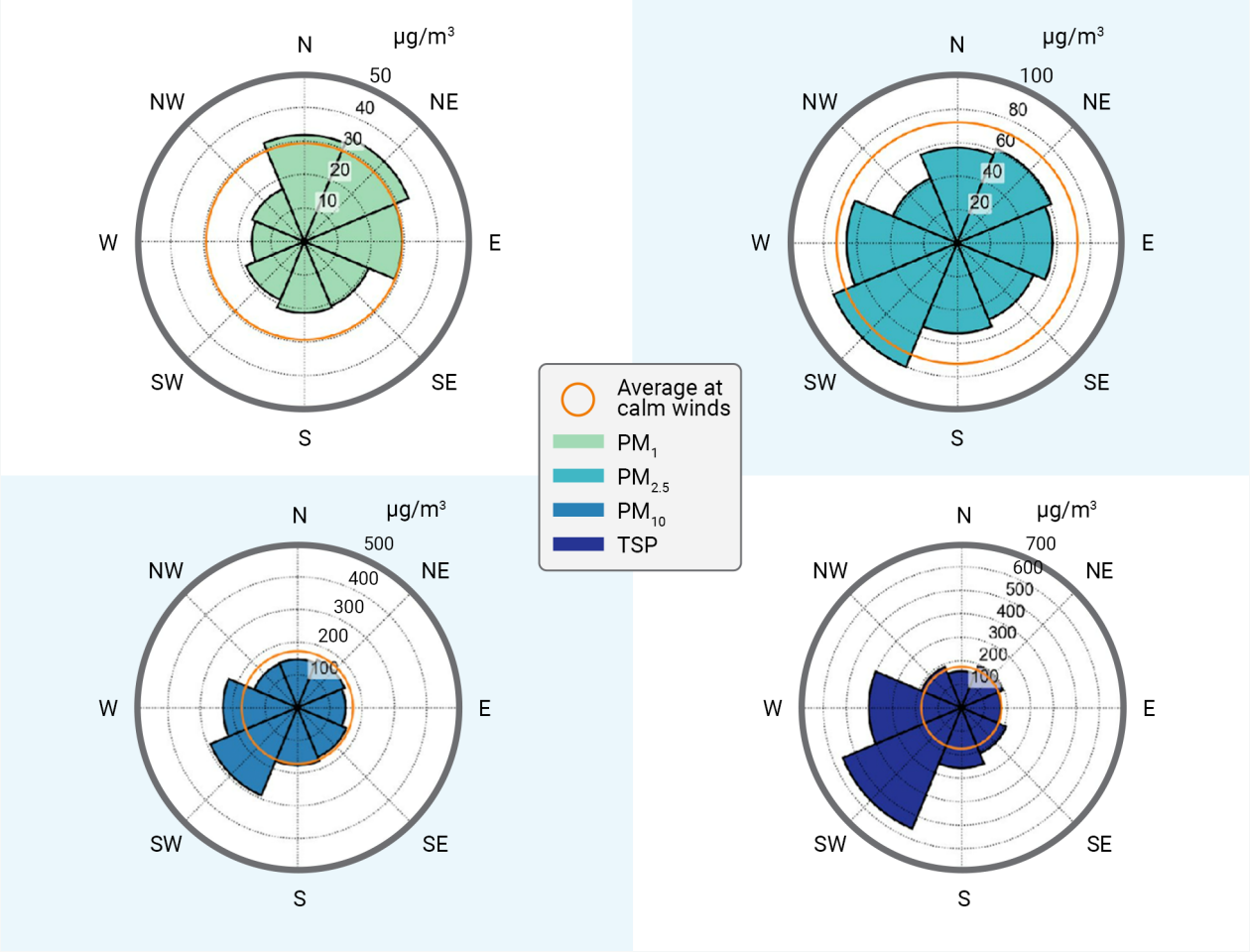
Particulate matter (PM) concentrations in Termez exceed all international and national health-based limits throughout the year. The annual average concentrations for 2024 reached 187 µg/m³ for PM_{10} and 55 µg/m³ for $PM_{2.5}$, significantly exceeding the WHO Air Quality Guidelines, including the Interim Target 1 thresholds (70 µg/m³ for PM_{10} and 35 µg/m³ for $PM_{2.5}$), as well as Uzbekistan's national maximum permissible one-time concentration (MPC) value for annual mean concentrations (50 µg/m³ for PM_{10} and 35 µg/m³ for $PM_{2.5}$). Air quality in Termez is among the most challenging in Uzbekistan, with consistently elevated levels of particulates observed across all seasons. While concentrations of gases such as NO_2, SO_2, CO, and O_3 remained low, concerns regarding data quality and calibration issues limit their reliability for quantitative analysis. In contrast, PM data were considered robust and formed the scientific basis of the report's conclusions.

Health and economic consequences of poor air quality are substantial. While health impact estimates for the city of Termez are not yet available, the joint World Bank–IHME report (2016) on the cost of air pollution indicated that $PM_{2.5}$-related total welfare losses in Uzbekistan amounted to approximately 4.4 per cent (about US$ 6.7 billion) loss in GDP in 2013. More recent findings from the World Bank's Air Quality Assessment for Tashkent (2024) estimate welfare losses in Tashkent alone at US$ 488 million per year (around 0.5 per cent of GDP in 2023). Thus, minimizing human exposure to high PM concentrations should be prioritized. The size of airborne particles is a critical factor in determining the extent of adverse health effects. Smaller particles pose a greater risk as they can penetrate deep into the lungs and some even enter the bloodstream. Exposure to $PM_{2.5}$ represents the most serious air-pollution-related health risk, closely associated with cardiovascular and respiratory diseases, cancer, and premature mortality.

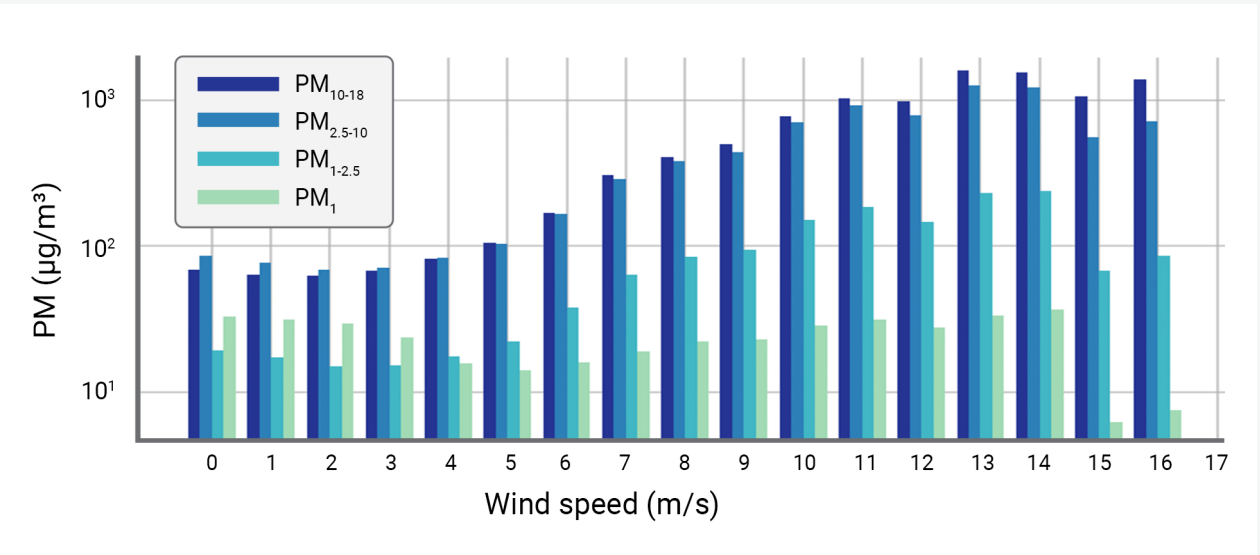
Air pollution in Termez does not affect all groups equally. Women face a heightened risk: global research shows links between air pollution and adverse reproductive and cardiovascular outcomes, including miscarriage, reduced fertility, and increased susceptibility to breast cancer and heart disease. According to national MICS 2021-2022 data, nearly half of households in Uzbekistan still rely on polluting fuels for heating and cooking, exposing women disproportionately, as they are often the primary household energy managers. Children and older people are also particularly vulnerable to the health impacts of air pollution. The report therefore integrates gender-responsive and socially inclusive measures to address air pollution in Termez.

Sand and dust storms (SDS) are a major contributor to PM pollution in Termez. Strong winds, especially from the southwest during the summer months, mobilize vast quantities of dust that significantly increase the concentrations of PM_{10} and $PM_{2.5}$. Data show a clear increase in coarser particle fractions (PM_{10} and TSP) with wind speed, confirming the impact of wind-driven dust resuspension. The city's proximity to arid landscapes amplifies the availability of loose sediments, while regional and transboundary SDS events further exacerbate exposure and degrade air quality.

Pollution rose plots for PM_1, $PM_{2.5}$, PM_{10} and TSP, measured at UzHydromet site in Termez. For $PM_{2.5}$ and PM_{10} data were available from 11 May 2023 to 31 December 2024; for PM_1 and TSP - from 10 March 2024 to 31 December 2024



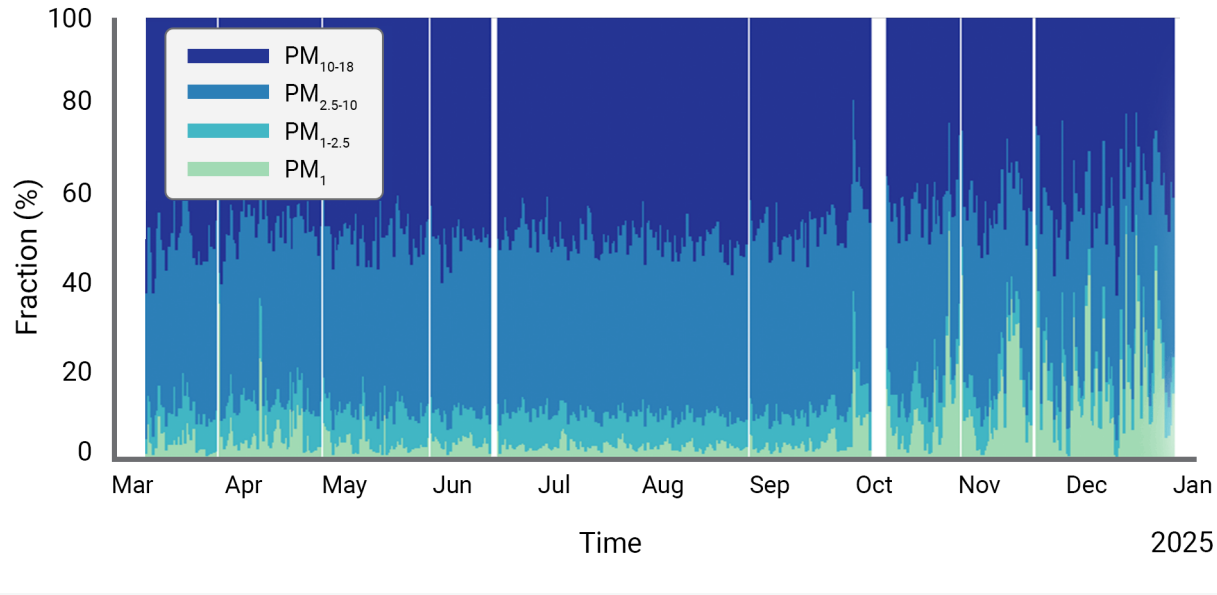
Average hourly PM mass at given wind speeds at each size range (< 1, 1-2.5, 2.5-10 and 10-18 µm)



Early warning systems, risk communication, and public health advisories are urgently needed to address SDS episodes. Termez, and Uzbekistan more broadly, would benefit from strengthened regional cooperation with neighboring regions and countries on data sharing, forecasting, and joint response measures. These efforts should be complemented by sustainable land management, reforestation, and land stabilization interventions aimed at reducing primary dust sources and enhancing ecosystem resilience.

Local domestic heating and other combustion activities significantly worsen wintertime air quality in Termez. During colder months, high concentrations of $PM_{2.5}$ and PM_{1} are observed, coinciding with low temperatures and calm wind conditions. These peaks are accompanied by elevated levels of combustion tracers such as CO and NO, which indicate local heating emissions. The available evidence suggests that fuels in addition to natural gas are used for winter heating, although more detailed data on fuel types are needed to design and target effective mitigation measures.

Time series of fraction of each size range (< 1, 1-2.5, 2.5-10 and >10-18 µm) of PM out of the total mass from March 2024 to December 2024 at hourly resolution



Addressing emissions from heating is a top priority for reducing local air pollution in Termez. Emission reduction strategies should begin with identifying and progressively phasing out polluting fuels used in winter heating. It is likely that coal, oil products, waste, or biomass are still being used, despite the availability of natural gas. Transitioning to cleaner fuels and technologies, improving household energy efficiency, and strengthening public awareness and enforcement are required to reduce severe wintertime pollution episodes.

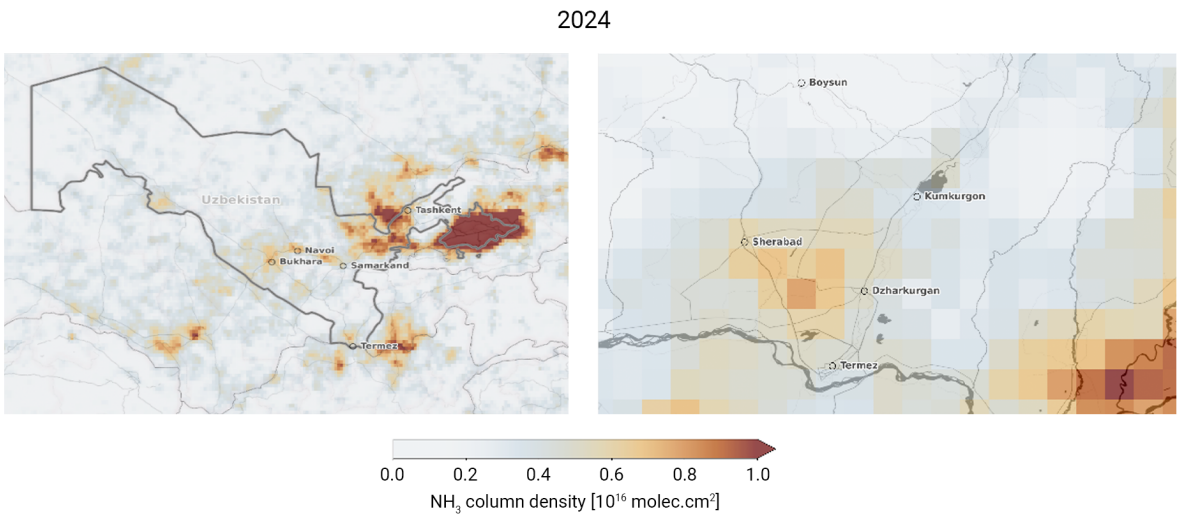
Traffic contributes to particulate levels through both exhaust emissions and road dust resuspension. Even as natural gas is the dominant vehicle fuel in Termez and across Uzbekistan, road traffic still contributes to $PM_{2.5}$ and PM_{10} pollution through non-exhaust emissions such as road dust resuspension. Nitrogen dioxide (NO_2) levels are likely linked to traffic, although the

monitoring station located in a park away from major roads, and the limited quality of the NO_2 dataset prevents firm conclusions. NO_2 concentrations are typically highest near the busy roads and city centers. Targeted measures to reduce vehicles-induced dust and promote cleaner, low-emission mobility options are essential for improving urban air quality in Termez.

Traffic, energy production, and industry remain key sectors requiring targeted emission controls. Even with natural gas as a vehicle fuel, resuspended dust continues to be a major source of particulate matter. Actions such as promoting cleaner and low-emission vehicles, enforcing vehicle emission standards, expanding electric mobility infrastructure, and implementing regular urban dust suppression measures are essential. For the energy and industrial sectors, priority measures include the transition to cleaner fuels and technologies, strict enforcement of emission limits, and the strengthening of environmental permitting, monitoring, and inspection systems.

Ammonia emissions are considerably high in Termez and can be a noteworthy source of secondary $PM_{2.5}$. Ammonia (NH_3) concentrations in Termez are high both in ground measurements and satellite retrievals, indicating substantial and spatially widespread emissions. The likely sources are agricultural activities, including intensive fertilizer application and livestock farming. Conducting a dedicated sampling campaign to analyze the chemical composition of $PM_{2.5}$ (anions and cations) would provide valuable insight into the contribution of ammonia to secondary particulate formation in the Termez area. Enhanced management of ammonia emissions through both policy and technical interventions is essential. Further research should be undertaken to identify and quantify specific NH_3 emission sources in and around Termez. Mitigation options include optimizing fertilizer use, improving manure management, and promoting low-emission agricultural practices. Implementing these measures would directly reduce secondary $PM_{2.5}$ formation and deliver substantial public health benefits.

Annual mean of NH_3 concentrations over Uzbekistan (left) and Termez area (right) in 2024 obtained from IASI instruments onboard Metop-B and -C satellites





Dust on the leaves of a city tree in Termez
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Air quality monitoring at the automatic monitoring station in Termez is constrained by data quality limitations and the relatively short operating period. While particulate matter data are considered reliable, measurements of gaseous pollutants (SO_2, NO_2, and O_3) have been affected by instrument signal drift and inadequate calibration, resulting in high measurement uncertainty and rendering parts of the dataset unusable. The 20-month monitoring period also limits the ability to assess long-term trends. There is a critical need to strengthen quality assurance and quality control procedures, ensure regular maintenance and multipoint calibration of instruments, and enhance technical capacity for data validation and management. Developing in-country expertise in quality assurance and quality control for air quality monitoring should be prioritized before further expansion of the monitoring network.

There is no evidence of major industrial pollution sources within Termez itself, although regional impacts are evident. No large-scale stationary emitters have been identified within the city. However, satellite observations indicate strong SO_2 signals from the Boysyn gas processing plant approximately 100 km north. Smaller-scale industrial and construction activities, such as soil processing, material handling, and roadworks, may contribute to localized particulate matter emissions, particularly under dry and windy conditions. In addition, the use of waste oil products for heating greenhouses during the cold season likely adds to the local air pollution burden.

More studies are needed to quantify the relative contributions of individual pollution sources. A robust source apportionment effort should include at least a one-year monitoring campaign involving systematic PM sample collection, detailed chemical composition analysis, and parallel monitoring of key gaseous pollutants, followed by receptor modeling. Such an approach would enable the city to determine the proportional contributions of emissions from traffic, residential heating, agriculture, natural dust, and other sectors – critical information for prioritizing control measures, targeting investments, and optimizing resource allocation. It would also allow for quantification of the influence of natural sources on PM_{10} and $PM_{2.5}$ concentrations.

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