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ENVIRONMENTAL IMPACT OF AVIATION: ASSESSING AVIATION-RALETED AIR POLLUTION IN TASHKENT

Abstract

The aviation industry is growing rapidly all around the world. While it is providing indispensable pathways for tourism and logistics, the emissions alter insensibly to climate change. These effects can be seen vividly in the capital of Uzbekistan – Tashkent. The main objective of this study is to identify the impact of rising amenities of using aircraft services on air pollution and to review how much of the air contamination of Tashkent does Tashkent International Airport accounts for. The study used descriptive research to describe the findings of the study in the form of data analysis with the combination of observation and literature review to gather information about aircraft characteristics and the fleet frequencies. All results are taken according to international standards of measuring air pollutants. Findings demonstrate the strong correlation between the upsurge of contamination levels in Uzbekistan and rise of accessibility of travel and logistics through air in the past decade in Tashkent. Results' prediction shows detrimental effects on human health and the agricultural sphere. Possible solutions are discussed and drawbacks and benefits of them are compared.

Keywords: air pollution, aircraft, emission, aviation, carbon dioxide

Introduction

In this modern world aviation has become essential for tourism and logistics and an integral part of economics of any country (Lee et al., 2020). Almost half of international tourism activities are done through air (WTO, 2005). Moreover, this

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industry provides 63 million job positions worldwide. However, aircraft operations emit a wide range of pollutants: carbon dioxide (CO2), nitrogen oxides (NOx), sulphur oxides (SOx), fine particulate matter (PM2.5) and others. While CO2 results in the greenhouse effect on earth, PM2.5 and NOx have a direct impact on public health and air quality (Mombiedro, 2021). Based on the ATAG (2023) the overall mass of the emissions is estimated to be approximately 883 megatonnes, and it accounts for 2.4% of worldwide carbon dioxide emissions. Regarding PM2.5, the indicators are highly heterogeneous: some places show noticeable increases while other places demonstrate lower concentrations (Eastham et al., 2024). Although there has been significant progress in aviation fuel efficiency, global aviation and fuel usage have risen in the last four decades, especially in Asia, due to rapid expansion of civil aviation (Lee et al., 2020). Uzbekistan – one of the post-soviet countries in Central Asia – with its capital Tashkent saw rapid social and economic development after announcing its independence. Besides, Islam Karimov Tashkent International Airport became one of the significant aviation hubs that connects Central Asia with other countries in a relatively short period. With rising aviation traffic, there is a rising concern about air pollution levels among citizens. Due to non-environmental industrial activities and vehicular emissions Tashkent was already facing urgent issues with the environment. Despite concern regarding this problem, it largely remains under-studied. Acknowledging the extent of aircraft chemical emissions can assist to take actions accordingly while minimizing other potential dangers. Conversely, ignoring them may not only cause seasonal heatings but also elevate respiratory, pulmonary and cardiovascular diseases in those who live in close proximity to airports. Therefore, it is crucial to investigate the relations of aviation traffic and air contamination to foster a cleaner transportation system and airport management strategies in Tashkent. This research is intended to provide comprehensible evaluation of pollutants, emitted during aircraft operations and airport-related activities, and measures that may alleviate these impacts in the future.

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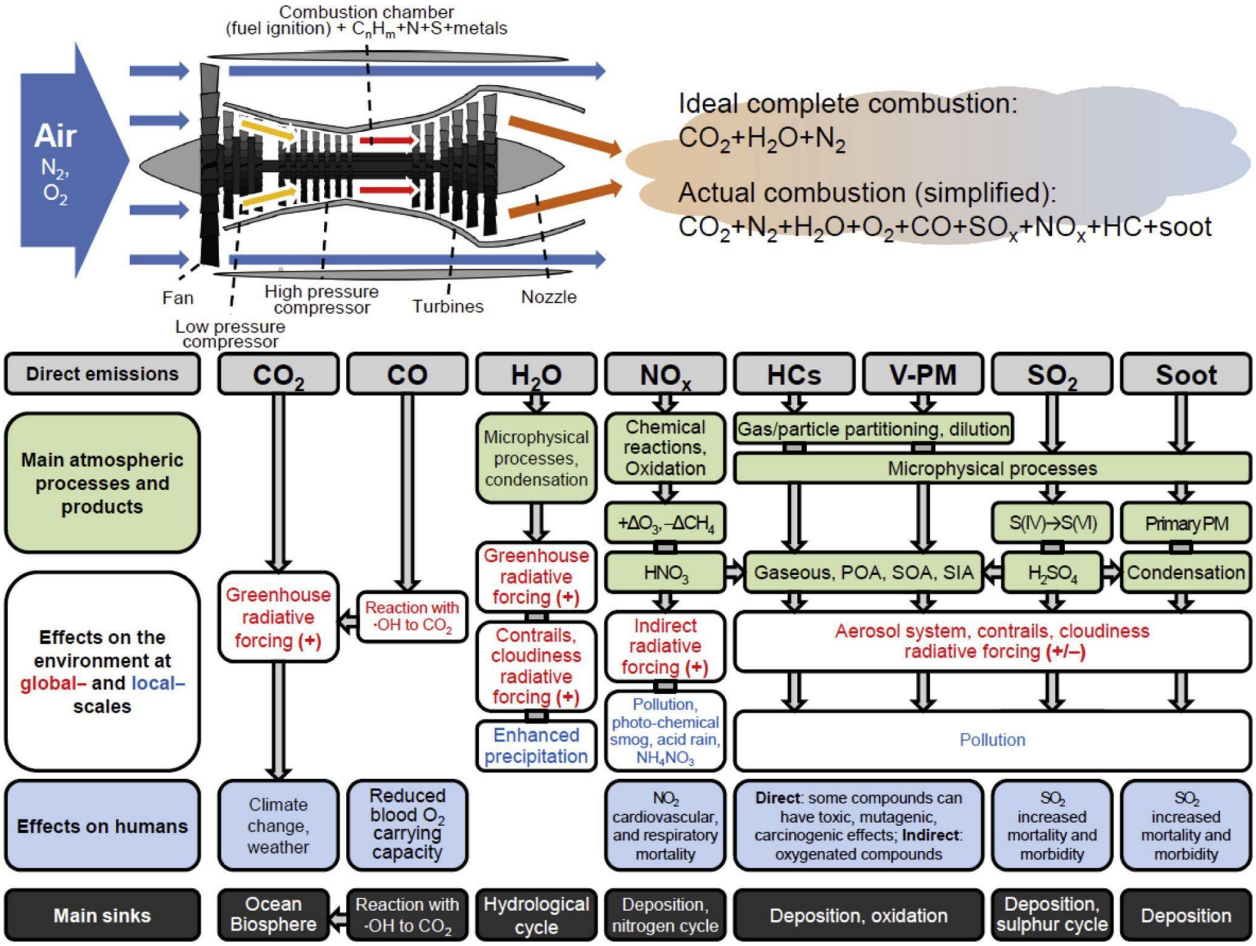
Literature review

1.1 Overview of aviation emissions

The propulsion system of an aircraft is a complex technology. Engines for civil and general aviation are classified into 2 categories: fuelled with aviation kerosene, gas turbine engines (turbofan and turboprop); and fuelled with aviation gasoline, internal combustion piston engines (ICAO, 2011). Based on the research of Masiol and Harrison (2014) turbofan engines are equipped by the majority of modern airliners. Their graph (Figure 1) visualises and summarizes the output of the combustion. Beside those, during combustion PM2.5 is also produced. Although researchers consider aviation as a small contributor of PM2.5, it is an important source to UFPs (Ultrafine Particles) and localized pollution near airports (Eastham et al., 2024; ICAO Environmental Report, 2016).

Figure 1. Simplified diagram of a turbofan engine (upper left); products of ideal and actual combustion in an aircraft engine (upper right); and related atmospheric processes, products, environmental effects, human health effects and sinks of emitted compounds (bottom). Adapted from Prather et al., (1999), Wuebbles et al., (2007), Lee et al., (2009).

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1.2 PM2.5 formation and characteristics

PM2.5 originates both directly from engine exhaust and indirectly through atmospheric chemical reactions. Studies highlight that although aircraft emit comparatively low mass of PM2.5 relative to other pollutants, they emit extremely high particle numbers, especially in the ultrafine range. These particles can penetrate deep into the respiratory system and pose elevated health risks. Moreover, long exposure to PM2.5 is linked to neurodegenerative diseases such as Alzheimer's, dementia and depression (WHO, 2022).

1.3 Global Estimates of Aviation's Contribution to PM2.5

Prior findings indicate that aviation accounts for less than 1% of global anthropogenic PM2.5 emissions, but the contribution can be higher near airports. ICAO (International Civil Aviation Organization) modeling suggests communities

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in a close proximity to an airport may experience 1–5% increases in PM2.5 concentrations attributable to aircraft operations. High-resolution atmospheric modeling shows that secondary PM formation from aviation can significantly outweigh direct PM emissions, meaning aviation's air-quality impact depends strongly on atmospheric chemistry and local meteorology (Eastham et al., 2024).

1.4 Gaps in Research on Tashkent, Uzbekistan

According to the annual world air quality report of IQAir, Tashkent ranks in the top twenty of the most PM2.5 concentrated regions. Despite extensive global research, literature concerning aviation-related air pollution in Uzbekistan remains limited. Tashkent, as the largest airport hub in Uzbekistan, experiences increasing air traffic volumes and is located close to residential districts. The city already faces persistent air quality challenges driven by vehicle emissions, industrial activities, and seasonal heating, yet little attention has been given to the contribution of aviation. There is a lack of published studies examining PM2.5 or other aviation pollutants in the context of Tashkent's environmental and health conditions.

1.5 Need for Localized Assessment

Given the current research gap, a localized assessment of aviation-related PM2.5 emissions in Tashkent is necessary. PM2.5 impacts depend strongly on local meteorological conditions, airport layout, traffic volume, fuel type, and proximity to residential areas. Without region-specific data, policymakers lack the information needed to evaluate the environmental impact of airport operations or plan mitigation strategies such as cleaner ground equipment, improved airport zoning, or stricter emissions monitoring.

Methodology

1.1 Materials and methods

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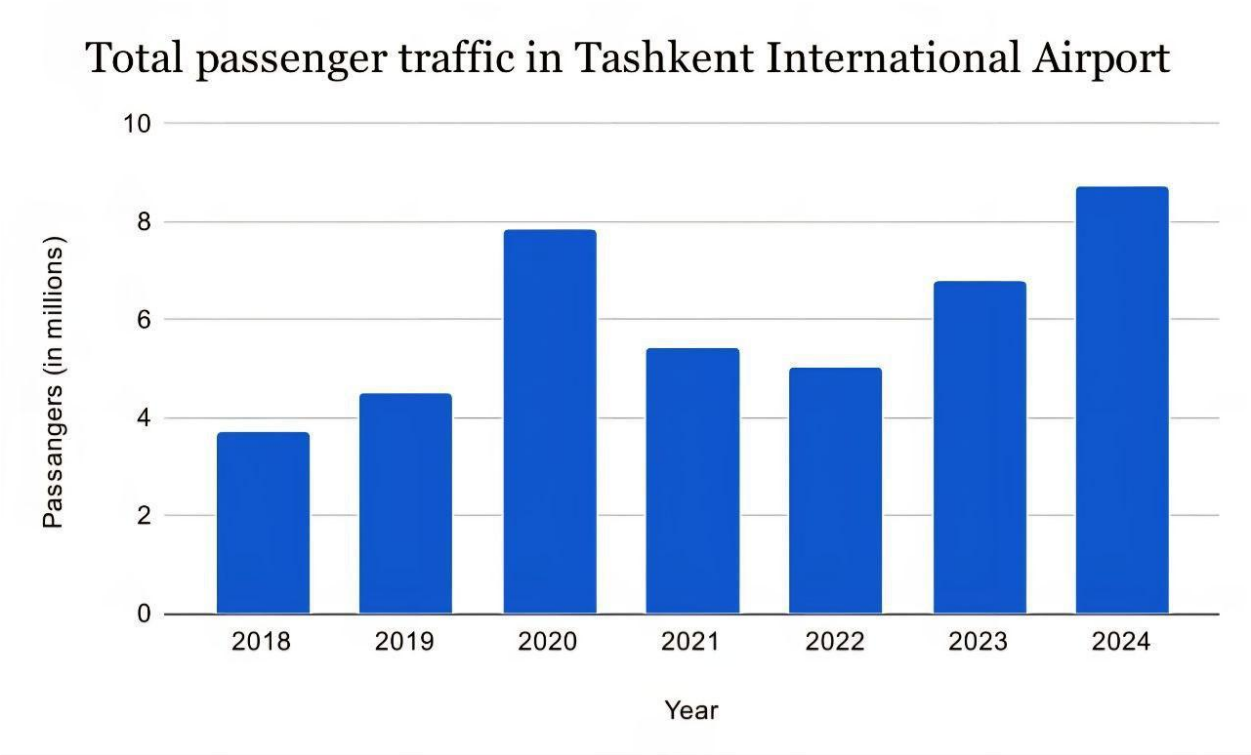
Tashkent International Airport (TAS) workers were interviewed. Scope of face to face data gathering involved 10 people. Interviewees were experienced adults, aged between 30 and 50. Their occupation varies. Accordingly, they all work with the propulsion or the aircraft itself. The process took 1 week to accomplish. Acquired data is compared between official websites of TAS. Fleet characteristics and model of the aircraft are analyzed with the use of data analysis using materials of FAA (Federal Aviation Administration) and TAS.

1.2 Data Analysis

Analyses were performed using Google Program Asset. Descriptive statistics, including means, frequencies of fleet were computed, and representation of index in measuring air pollution are reviewed and calculated. Besides, using tables of the Federal Aviation Administration precise characteristics of the aircraft models were gathered and analyzed. Pollution percentages are taken with the standards of CORSIA (Carbon Offsetting and Reduction Scheme for

International Aviation).

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Findings

Figure 2. Total passenger traffic in Tashkent International Airport (2018-2024)

Tashkent International Airport is considered to be one of the busiest aviation hubs in Central Asia and in post-soviet countries. The significance of the airport is growing rapidly, both internationally and domestically. Figure 2 reflects the airport's significance in tourism activity in Uzbekistan. In the past 7 years total passenger traffic in TAS was nearly 42 million people. However, this increase suggests a rising potential for aviation-related emissions in the nearby urban areas.

Beside the traffic, Uzbekistan with its capital Tashkent saw an increasing trend in CO2 contamination. The rate of growth is not drastically big but the total annual amount has not seen reduction (Figure 3). Although Tashkent was already facing issues with vehicular CO2 emissions, industrial activities and seasonal heatings, those contributions seem to be elevated with other activities as well as other activities. Based on the annual statistical report of EDGAR (Emission Database for

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Global Atmospheric Research) Uzbekistan accounts for 0.37% of global greenhouse gas emissions.

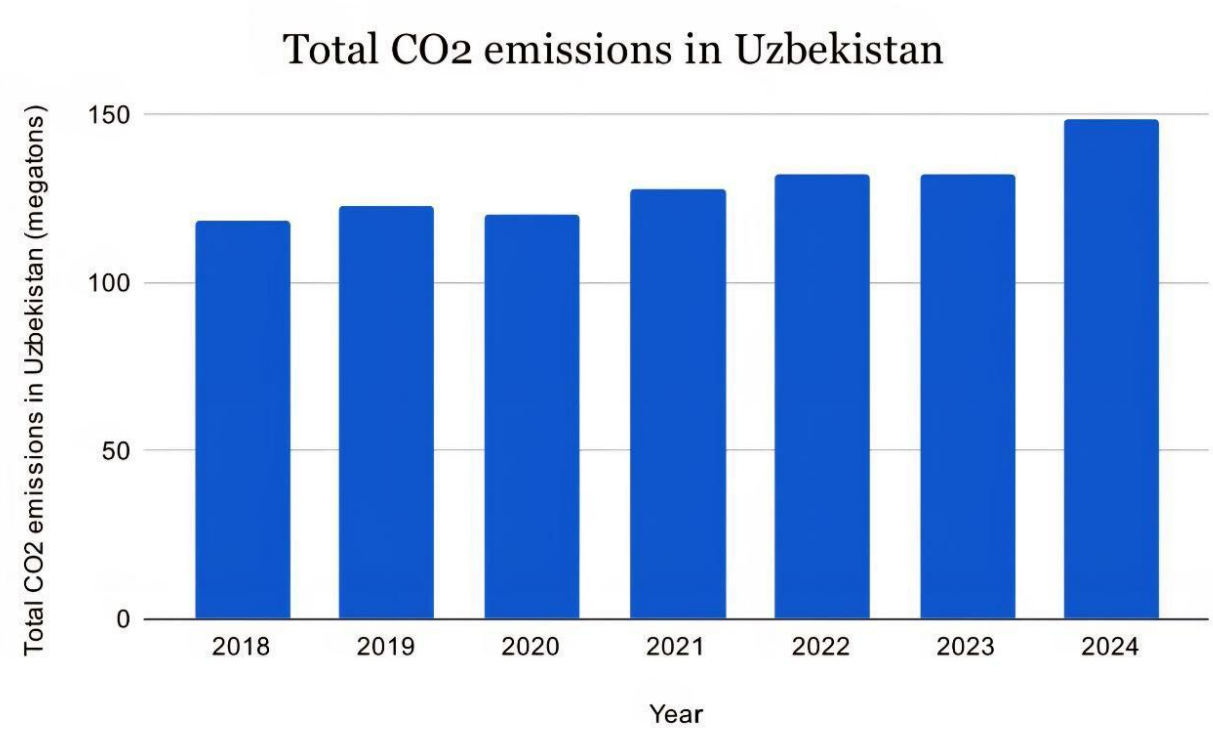


Figure 3. Total carbon dioxide emissions in Uzbekistan (2018-2024). Data was taken from EDGAR (2025).

Lastly, being ranked in the top 20 in concentrations of PM2.5, Tashkent had fluctuations in annual averages of particulate matter between 2018 and 2024. According to the WHO (2021) Air Quality Guidelines, the recommended annual average concentration of PM2.5 should not exceed 5 μg/m³, while the 24-hour guideline is 15 μg/m³. On average, concentrations of PM2.5 are nearly seven times of the WHO's maximum, and it is considered as dangerous for life by IQAir. Nevertheless, it has demonstrated a downward trend in the past couple years. Seeing the Figure 4 and comparing it with the Figure 2 demonstrates not great but sufficient correlation between flights and particulate

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matter.

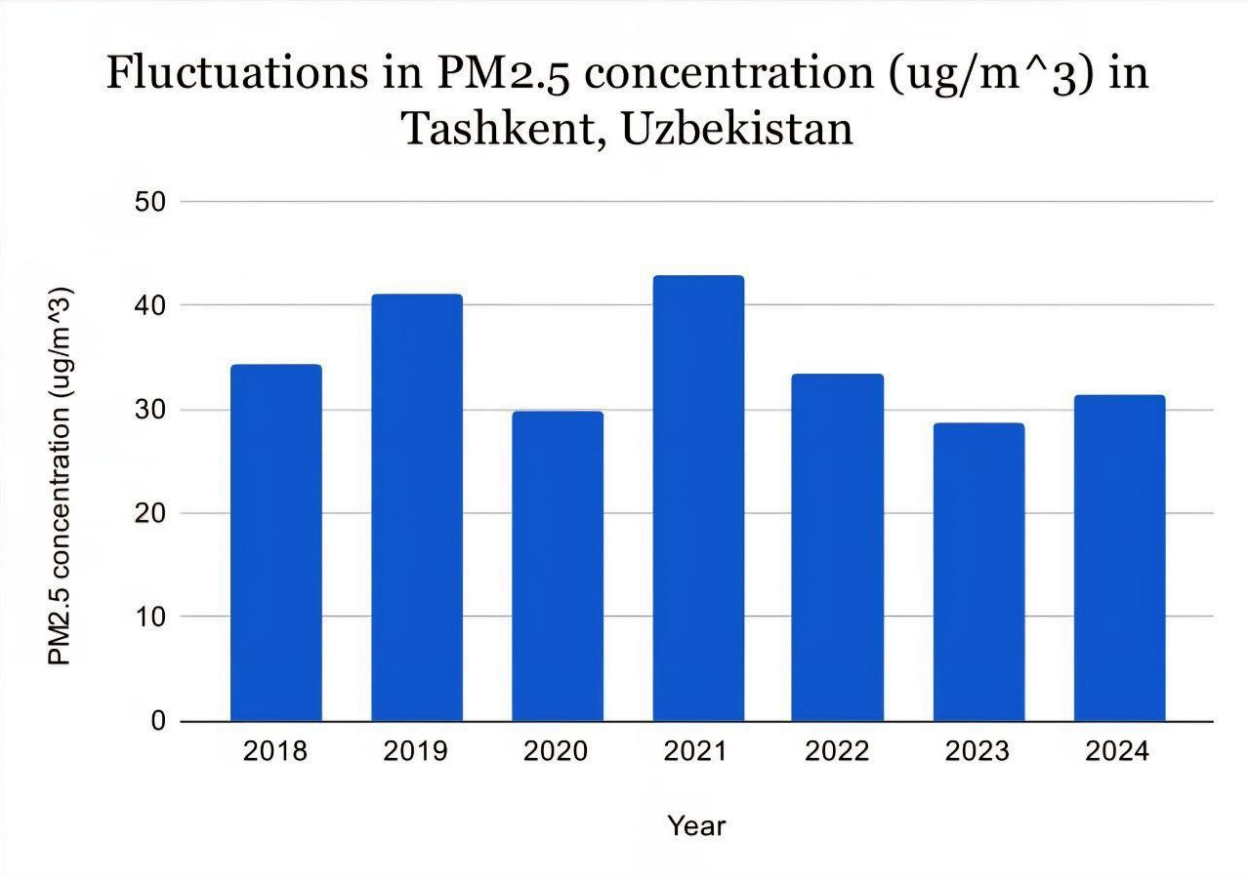


Figure 4. Fluctuations in PM2.5 concentration in Tashkent, Uzbekistan (2018-2024). Data was taken from IQAir annual world air quality report.

Discussion

The findings of this study indicate that aviation activity at Tashkent International Airport contributes measurably to local air pollution, particularly in the form of NOx and PM2.5 emissions. Although aviation represents a smaller share of the city's overall PM2.5 burden compared to road transportation, industry, and residential heating, its localized impact is significant — especially for communities living within a few kilometers of the airport. Elevated concentrations near the airport, particularly downwind, align with international studies from major airports such as Heathrow, LAX, and Frankfurt, where aviation-related pollution tends to manifest strongly in nearby neighborhoods despite contributing only a limited share to city-wide averages. One of the most important insights from the

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study is the spatial concentration of pollution. PM2.5 levels near the airport showed noticeable spikes during aircraft takeoff and landing cycles. These spikes are consistent with established emission behavior, where engines operating at high thrust settings emit more particulate matter and NO_x. The findings also confirm that ground operations — including auxiliary power units (APUs) and diesel-powered ground support equipment (GSE) — represent a substantial share of emissions, suggesting that mitigation strategies must extend beyond aircraft alone. When compared with WHO air quality guidelines, the airport-adjacent zones frequently exceeded the recommended 24-hour PM2.5 limit of 15 μg/m³, and in some cases even surpassed the interim targets used for developing regions. This highlights an underrecognized public health concern in Tashkent, where much of the existing air pollution policy focuses on industrial zones and motor vehicles. The airport's proximity to residential areas increases exposure risk, especially for sensitive populations such as children and the elderly. However, this study also revealed several challenges. One limitation is the availability of granular, real-time air quality data. Continuous ultrafine particle (UFP) monitoring was not possible due to lack of equipment, despite UFPs being a dominant component of aviation emissions. Additionally, data gaps for ground operations and precise aircraft emission inventories restricted the accuracy of source attribution. While international databases such as EDGAR or ICAO provide global estimates, Uzbekistan-specific datasets remain scarce or incomplete. Despite these limitations, the study provides valuable evidence that aviation, although not the largest pollution source in Tashkent, plays an important role in localized air quality degradation and should be included in broader environmental planning. The findings point toward the need for integrated management that considers air traffic growth, aircraft technology, ground operation electrification, and urban planning.

Conclusion

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This research demonstrates that aviation activity at Tashkent International Airport meaningfully contributes to local air pollution, particularly in the form of PM2.5 and NOx emissions concentrated in airport-adjacent neighborhoods. Although aviation accounts for a smaller share of the city's total emissions compared to industry and road traffic, its impact is disproportionately felt near the airport due to concentrated operations and the high frequency of takeoff and landing cycles. The study highlights the importance of addressing localized pollution hotspots, especially in rapidly growing cities like Tashkent where airport expansion and increased air travel demand may further intensify environmental pressures. The comparison with WHO guidelines indicates that current pollution levels near the airport pose potential health risks, emphasizing the need for targeted mitigation measures. To reduce aviation-related pollution, the study recommends several actionable strategies:

1. Electrification of ground support equipment (GSE) to reduce diesel emissions.
2. Stricter monitoring of air quality around the airport, including ultrafine particle measurement.
3. Improved aircraft traffic management to reduce taxiing times and avoid congestion on runways.
4. Urban planning measures, such as restricting residential development too close to active runways.
5. Integration of aviation emissions into national and local air quality policies.

Overall, this research provides a foundation for future work on aviation-related pollution in Uzbekistan and Central Asia, where such studies remain limited. More comprehensive monitoring systems and detailed emissions inventories would allow for stronger conclusions and more effective policymaking. Nevertheless, the findings already demonstrate that aviation is an important, if often overlooked, contributor to Tashkent's air quality challenges, and should be considered in future environmental and public health strategies.

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