

Vehicular Pollution in Tourist Cities: A Case Study of Agra's Air Quality and Health Outcomes

Dr. Dinesh Kumar Tomar

Assistant Professor, Department of Zoology, Government Degree College Kursanda, Hathras, Uttar Pradesh, INDIA.

Corresponding Author: drdstomar@yahoo.co.in



www.jrasb.com || Vol. 4 No. 5 (2025): October Issue

Received: 15-10-2025

Revised: 18-10-2025

Accepted: 20-10-2025

ABSTRACT

Tourist cities face a dual burden of maintaining heritage integrity while coping with rising vehicular emissions. Agra, globally renowned for the Taj Mahal, experiences intense traffic due to tourism, commercial growth, and urban expansion. This influx has made vehicles a dominant source of air pollution, releasing fine particulates (PM_{2.5}), nitrogen oxides (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO), and volatile organic compounds (VOCs). Elevated levels of these pollutants deteriorate ambient air quality and are strongly linked to respiratory problems, cardiovascular stress, and impaired cognitive function among residents and visitors. Beyond human health, corrosive deposits of pollutants accelerate the discoloration and structural decline of marble monuments, posing a serious challenge to cultural conservation.

Policy frameworks such as the transition to Bharat Stage VI standards, partial traffic restrictions near the Taj Mahal, and wider use of compressed natural gas (CNG) reflect important mitigation steps. However, their impact remains uneven due to limited enforcement, inadequate infrastructure, and the continued dominance of private vehicles. This case study highlights the pressing need for comprehensive interventions, including sustainable transport systems, stricter emission monitoring, and eco-sensitive tourism models. Protecting Agra's air quality and safeguarding its heritage demand a balanced strategy where environmental sustainability and tourism coexist without compromise.

Keywords- Vehicular emissions, Agra, air quality, public health, cultural heritage, sustainable transport.

I. INTRODUCTION

Vehicular pollution has become a defining environmental challenge of the 21st century, particularly in urban centers that serve as major tourist hubs. With rapid urbanization, rising disposable incomes, and increased mobility, the number of vehicles on city roads has expanded exponentially. While transportation remains essential for economic and social development, the associated emissions—especially in cities already experiencing tourism-related congestion—pose severe risks to air quality, human health, and the built environment (Gurjar et al., 2016; World Health Organization [WHO], 2022). Tourist destinations such as Delhi, Bangkok, Rome, and Beijing have reported similar concerns, where elevated levels of pollutants are strongly correlated with dense traffic patterns, particularly during peak tourist seasons (Colville et al., 2001; Molina & Molina, 2004; Li et al., 2019).

Agra, one of India's most visited cities and a global heritage destination, provides a particularly compelling context for analyzing vehicular pollution. Known worldwide for the Taj Mahal, Agra attracts more than ten million domestic and international visitors annually (Government of India, Ministry of Tourism, 2023). The influx of tourists has created exceptional traffic density around heritage zones and arterial roads, intensifying pollution loads in an already vulnerable environment (Nagpure et al., 2016; Guttikunda et al., 2019). Unlike many modern cities, Agra faces the compounded challenge of balancing economic benefits from tourism with the urgent need to safeguard both public health and fragile cultural heritage (Sharma & Roy, 2017, 2021).

Recent research has quantified the magnitude of these impacts in Agra. Long-term monitoring shows significant contributions of traffic emissions to particulate pollution, with size-segregated particles enriched in toxic



metals at busy junctions (Tiwari et al., 2022, 2023). Source apportionment studies further confirm that vehicular activity is a dominant contributor to PM_{2.5}, PM₁₀, and total suspended particles in the vicinity of the Taj Mahal (Atmospheric Pollution Research, 2021). The consequences extend beyond air quality degradation: pollutant exposure is linked with heightened respiratory, cardiovascular, and carcinogenic risks for local residents and tourists (Maji et al., 2017; Kushwaha et al., 2025). Furthermore, pollutant deposition accelerates the discoloration and deterioration of marble monuments, most notably the Taj Mahal, which has exhibited visible yellowing and surface erosion (Bergin et al., 2003; Beig et al., 2021).

Against this backdrop, the present paper sets out four objectives. First, it examines vehicular emissions as a key driver of Agra’s deteriorating air quality within the broader context of tourist cities. Second, it highlights the specific pollutants of concern and their impacts on public health and heritage structures. Third, it reviews existing mitigation strategies—including Bharat Stage VI emission norms, restrictions on vehicle movement near the Taj Mahal, and adoption of compressed natural gas (CNG)—and evaluates their effectiveness. Finally, the study underscores the urgent need for sustainable transport systems, robust emission monitoring, and eco-sensitive tourism practices to reconcile the demands of economic growth with the imperatives of environmental and cultural preservation.

II. SOURCES OF VEHICULAR POLLUTION IN AGRA

Table 1: Key Sources of Vehicular Pollution in Agra

Source / Factor	Vehicle Types Involved	Key Pollutants Emitted	Impact Notes
Fleet growth	Private cars, taxis, two-wheelers	PM _{2.5} , PM ₁₀ , NO _x , CO, VOCs	Overall rise in urban air pollution
Seasonal tourist surges	Tourist buses, taxis, auto-rickshaws	PM _{2.5} , PM ₁₀ , NO _x , CO, VOCs	Peak pollution during winter/holiday periods
Traffic congestion & idling	All vehicle types	PM _{2.5} , PM ₁₀ , NO _x , CO, hydrocarbons	Idling leads to higher localized pollutant concentrations
Diesel and older vehicles	Diesel buses, auto-rickshaws	PM _{2.5} , NO _x , black carbon	Health risks and heritage damage; inefficient fuel combustion

This structured approach shows that vehicular pollution in Agra results from a combination of fleet expansion, tourism-induced traffic peaks, congestion, and diesel dependency. Mitigation requires coordinated measures: stricter emission monitoring, promotion of CNG and electric vehicles, better traffic management, and sustainable transport solutions tailored to the city’s heritage zones.

III. AIR QUALITY STATUS OF AGRA

Agra’s air quality has been a growing concern due to vehicular emissions, industrial activity, and

Vehicular emissions are the primary contributors to Agra’s deteriorating air quality. Several interrelated factors amplify their intensity as described here:-

Rapid Growth of Vehicular Fleet: Over the last two decades, Agra has witnessed a steep increase in private vehicles, taxis, auto-rickshaws, and tourist buses. The surge in vehicle numbers, fueled by rising domestic tourism and urban expansion, has significantly increased exhaust emissions (Maji et al., 2017; Kushwaha et al., 2025).

Tourism-Driven Traffic Peaks: With more than ten million visitors annually, Agra experiences pronounced traffic congestion during peak tourist seasons, especially near heritage sites such as the Taj Mahal, Agra Fort, and Fatehpur Sikri. These periods coincide with spikes in particulate matter (PM_{2.5}, PM₁₀), nitrogen oxides (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO), and volatile organic compounds (VOCs) (Tiwari et al., 2022; Atmospheric Pollution Research, 2021).

Traffic Congestion and Idling: Narrow roads and insufficient parking infrastructure result in vehicle idling, particularly around tourist zones. Studies report that idling and slow-moving traffic contribute disproportionately to emissions of hydrocarbons, CO, and NO_x, along with toxic metals in fine particulates (Tiwari et al., 2023).

Diesel Use and Vehicle Age: Diesel-powered vehicles, including buses and auto-rickshaws, remain widespread. Older vehicles lacking modern emission controls emit higher levels of PM and NO_x, despite policy initiatives promoting CNG and Bharat Stage VI-compliant engines (Nagpure et al., 2016).

seasonal variations. Monitoring from the Central Pollution Control Board (CPCB) and System of Air Quality and Weather Forecasting and Research (SAFAR) provides critical insights into the city’s pollution patterns.

AQI Trends

Agra’s AQI typically ranges from moderate to poor, with worst levels observed during the winter months. Factors contributing to higher AQI include:

- Increased vehicular traffic during peak tourist seasons.
- Industrial emissions from nearby zones.
- Stubble burning in neighboring regions.

Comparative Analysis

Compared to other heritage cities, Agra’s air quality is relatively better than Delhi, which often records severe AQI, but worse than Jaipur during non-peak seasons. Episodes of smog and haze are frequent in winter, reducing visibility of monuments and impacting tourism.

Proximity of Pollution Hotspots

Areas surrounding the Taj Mahal, especially along arterial roads and near industrial pockets, are major pollution hotspots, contributing significantly to particulate matter deposition on marble surfaces, India Today. (2024)

Table 1: Air Quality Status of Agra and Comparative Heritage Cities

Parameter	Agra	Delhi	Jaipur	Notes
Average AQI (2023)	152 (Moderate–Poor)	320 (Severe)	120 (Moderate)	Data from CPCB/SAFAR
Peak Season AQI	180–220 (Winter)	400+ (Winter)	140–160 (Winter)	AQI spikes during tourist season and winter smog events
Main Pollutants	PM _{2.5} , PM ₁₀ , NO _x , CO, SO ₂	PM _{2.5} , PM ₁₀ , NO _x , SO ₂ , O ₃	PM _{2.5} , PM ₁₀ , NO _x	Vehicle emissions dominant
Smog/Haze Episodes	Frequent in December–January	Severe, multiple episodes	Occasional	Winter temperature inversion + biomass burning
Proximity to Heritage Sites	High near Taj Mahal & Agra Fort	High in city center	Moderate near Amer Fort	Direct impact on monument visibility and heritage degradation
Vehicular Density Influence	High	Very High	Moderate	Tourist buses, taxis, private cars

IV. PUBLIC HEALTH OUTCOMES IN AGRA DUE TO AIR POLLUTION

Respiratory Illnesses

- Asthma & Chronic Obstructive Pulmonary Disease (COPD): Exposure to elevated levels of PM10 and PM2.5 in Agra has been linked to increased incidences of asthma and COPD. Children are particularly vulnerable, with studies indicating a higher risk of acute respiratory infections and decreased lung function due to air pollution exposure. PMC

Cardiovascular Diseases

- Increased Risk: Long-term exposure to air pollutants such as PM2.5 and NO2 is associated with a heightened risk of cardiovascular diseases. Older adults and individuals with preexisting conditions are especially at risk. PMC

Impact on Vulnerable Groups

- Children: Children are more susceptible to the adverse effects of air pollution due to their developing respiratory systems and higher breathing rates. They face increased risks of respiratory infections, asthma, and reduced lung development. PMC
- Elderly: Older adults experience more severe health outcomes from air pollution, including exacerbated cardiovascular and respiratory conditions.
- Traffic Police & Roadside Vendors: Individuals exposed to traffic-related pollution are at increased risk of respiratory and cardiovascular diseases due to prolonged exposure to harmful pollutants.

Cognitive and Neurological Risks

- Emerging Studies: Recent research suggests that air pollution may have detrimental effects on cognitive functions, particularly in children and the elderly. However, more studies are needed to fully understand these impacts. ScienceDirect

Hospital Admission and Mortality Trends

- Hospital Admissions: Long-term exposure to air pollution is linked to increased hospital admissions for respiratory and cardiovascular diseases. A systematic review found a significant association between air pollution and total hospital admissions. PMC
- Mortality Trends: Studies have shown that elevated levels of air pollution contribute to increased mortality rates, particularly from respiratory and cardiovascular diseases. World Health Organization

V. HERITAGE AND ECOLOGICAL CONCERNS OF THE TAJ MAHAL

Discoloration of Marble Due to Pollution

The Taj Mahal's iconic white marble has been undergoing discoloration, turning yellow, brown, and green. This change is primarily attributed to:

- Air Pollution:** Emissions from vehicles and nearby industries release sulfur dioxide (SO2) and nitrogen oxides (NOx), leading to acid rain that corrodes the marble's surface The Independent.
- Particulate Matter:** Carbon-based particles from burning fuels and garbage settle on the marble, causing a yellowish sheen.

- **Insect Excreta:** Insects breeding in the polluted Yamuna River deposit greenish droppings on the monument, further staining the marble Time for Kids.

Impact of Polluted Yamuna River

The Yamuna River, adjacent to the Taj Mahal, significantly contributes to its deterioration:

- **Hydrogen Sulfide Emission:** Pollution from untreated sewage and industrial effluents releases hydrogen sulfide (H₂S) into the air, which is more corrosive than sulfur dioxide and accelerates the decay of the marble Mongabay-India.
- **Microplastic Contamination:** A study by the Centre for Science and Environment found high concentrations of microplastics in the riverbed near the Taj Mahal, posing ecological threats Telegraph India.

Broader Ecological Effects

The environmental degradation extends beyond the monument:

- **Urban Vegetation:** Air pollution and acid rain damage trees and plants in the vicinity, affecting local biodiversity.
- **Soil Contamination:** Pollutants from the river and air settle on the ground, leading to soil degradation and impacting agriculture.
- **Flooding Risks:** Recent flooding of the Yamuna River has submerged parts of heritage sites like the 'Baby Taj' and Mehtab Bagh, highlighting the vulnerability of these structures to environmental changes The Times of India.

The Taj Mahal, a UNESCO World Heritage Site, faces significant threats from both air and water pollution. Immediate and sustained efforts are required to mitigate these impacts and preserve this iconic monument for future generations.

VI. POLICY AND MITIGATION MEASURES IN AGRA

Taj Trapezium Zone (TTZ) Regulations SwachhIndia / NDTV. (2018, July 25).

- In 1996, the Supreme Court of India mandated the creation of the Taj Trapezium Zone (TTZ), a 10,400 sq. km. eco-sensitive area around the Taj Mahal.
- The order directed relocation or conversion of polluting industries, phasing out of coal-based units, and promotion of clean fuels to protect the monument's marble from sulfur dioxide and particulate damage.
- Despite progress, enforcement gaps remain due to illegal operations and urban growth pressures.

Promotion of CNG-Based Vehicles

- Following the TTZ mandate, the Government of Uttar Pradesh promoted CNG adoption, particularly for auto-rickshaws, buses, and taxis.

- The conversion significantly reduced visible smoke emissions and sulfur pollutants.
- However, inconsistent supply of CNG and high costs of conversion continue to limit universal adoption.

Vehicle Entry Restrictions Near Taj Mahal

- Private vehicles are restricted from entering within 500 meters of the Taj Mahal complex.
- Battery-operated eco-vehicles, e-rickshaws, and horse-drawn tongas are encouraged to transport tourists from designated parking areas.
- This has reduced immediate exposure of the monument to vehicular exhaust, but surrounding arterial roads still remain congested.

Public Transport Initiatives

- Agra has introduced city bus services, e-rickshaws, and app-based ride-sharing options to reduce dependence on private vehicles.
- The Agra Metro Project, expected to be operational by 2025, is a major sustainable mobility intervention aimed at lowering emissions and easing congestion.

Limitations in Enforcement

- Weak monitoring of TTZ industries and vehicular emissions undermines policy effectiveness.
- Tourism-driven seasonal spikes in traffic strain the city's transport systems.
- Coordination challenges among agencies (CPCB, UPPCB, TTZ Authority, local administration) hinder effective implementation.
- Public awareness and behavioral change remain limited, reducing compliance with eco-friendly travel practices.

Agra has pioneered some of India's earliest air pollution control interventions, but vehicular pollution continues to threaten both public health and heritage conservation. Strengthening TTZ enforcement, expanding clean public transport, and promoting eco-tourism models are critical for sustainable urban management.

VII. RECOMMENDATIONS & FUTURE DIRECTIONS

Vehicular pollution in Agra requires **multi-pronged interventions** that align environmental sustainability with heritage preservation and tourism management. Several pathways can be emphasized for the future:

- **Green Mobility Solutions:** The gradual shift toward electric buses, battery-operated rickshaws, and hybrid taxis can significantly lower emissions. To accelerate adoption, government policies must ensure charging infrastructure, subsidies, and tax incentives. Public-private partnerships can further facilitate a robust clean-transport ecosystem.
- **Agra Metro Rail Project:** The upcoming Agra Metro Rail, which is designed to connect major heritage sites, commercial hubs, and residential

areas, offers a transformative opportunity to reduce traffic congestion and curb vehicular emissions. By providing a fast, reliable, and eco-friendly alternative, the metro system will encourage both residents and tourists to shift away from private cars and polluting vehicles. Integrating metro services with shuttle buses, e-rickshaws, and pedestrian-friendly pathways can maximize its environmental benefits.

- **Sustainable Tourism Practices:** As a UNESCO World Heritage city, Agra must prioritize tourism-centered eco-solutions. Establishing pedestrian-only zones around the Taj Mahal and Agra Fort, coupled with electric shuttle services from designated parking areas, can reduce localized emissions. Seasonal regulation of tourist inflows and carbon-offset programs for international visitors may further ease ecological stress.
- **Awareness and Behavioral Change:** Pollution control is not merely technological but also socially driven. Awareness campaigns targeting tourists, drivers, schoolchildren, and street vendors should highlight the direct links between air pollution, health risks, and damage to heritage monuments. Citizen engagement initiatives such as “Clean Air, Clean Heritage” programs can instill shared responsibility.
- **Smart City Integration:** Agra’s inclusion in India’s Smart City Mission provides a platform to implement real-time air quality monitoring, AI-enabled traffic management, and adaptive traffic signals. Coupling these with urban greening measures such as roadside plantations and buffer green belts can enhance resilience. Linking AQI improvement indicators with city governance benchmarks will strengthen accountability.

VIII. CONCLUSION

Vehicular pollution in Agra poses a triple challenge—threatening public health, accelerating the deterioration of cultural heritage, and contributing to environmental degradation. Rising emissions from cars, diesel buses, tourist vehicles, and auto-rickshaws have worsened respiratory and cardiovascular illnesses among residents, while also affecting vulnerable groups such as children, the elderly, traffic police, and roadside vendors. Beyond human health, the deposition of particulate matter and acidic gases has left visible marks on the Taj Mahal’s marble surfaces, raising global concerns over heritage conservation.

Policy measures such as the Taj Trapezium Zone (TTZ), the promotion of CNG vehicles, traffic restrictions near heritage sites, and improved public transport have offered partial relief. However, limited enforcement and the continuous growth of tourist inflows undermine their effectiveness. The upcoming Agra Metro Rail project, along with expanded use of electric mobility solutions, represents a promising pathway to curb emissions while

supporting both local commuters and the city’s millions of annual visitors.

Ultimately, the way forward lies in a holistic and integrated strategy—combining green mobility, sustainable tourism practices, stricter policy enforcement, smart city innovations, and widespread public awareness. By aligning urban development with heritage protection and ecological sustainability, Agra can transform into a model city that balances its tourism-driven economy with environmental health and cultural preservation. Such an approach is not only vital for Agra but also serves as a blueprint for other heritage cities worldwide grappling with similar challenges.

REFERENCES

- [1] Bergin, M. H., Tripathi, S., Schauer, J. J., Ramaswami, A., Russell, A., & Saxena, P. (2015). The discoloration of the Taj Mahal due to particulate air pollution: A review of sources, impacts, and mitigation. *Environmental Research Letters*, 10(1), 015002. <https://doi.org/10.1088/1748-9326/10/1/015002>
- [2] Central Pollution Control Board. (2022). *National air quality status & trends report (2011–2021)*. Ministry of Environment, Forest and Climate Change, Government of India. Retrieved from <https://cpcb.nic.in>
- [3] Commercial vehicles near Taj ordered to go CNG before July 31.” *The Times of India*. (2015, January 29). *Times of India* article. Retrieved from <https://timesofindia.indiatimes.com/city/agra/commercial-vehicles-near-taj-ordered-to-go-cng-before-july-31/articleshow/46058664.cms> The Times of India
- [4] CPCB. (2023). *Air Quality Index Bulletin*. Central Pollution Control Board. https://cpcb.nic.in/aqi_bulletin.php
- [5] EIB (European Investment Bank). (2021). *Agra Metro Rail Project: Environmental and social impact assessment*. Luxembourg: EIB. Retrieved from <https://www.eib.org/attachments/registers/143780383.pdf>
- [6] Emission Inventory and Modelling of Air Pollution Sources in Agra Region.” NEERI & IIT-Kanpur & partners. (2021). UNEP-IITK Final Report. Retrieved from https://home.iitk.ac.in/~mukesh/Publications/2021_UNEP-IITK-Final-Report-Emission-Inventory-and-Modelling-of-Air-Pollution-Sources-in-Agra-Region.pdf IIT Kanpur
- [7] Goyal, P., & Sidhartha. (2003). Present scenario of air quality in Delhi: A case study of CNG implementation. *Atmospheric Environment*, 37(38), 5423–5431. <https://doi.org/10.1016/j.atmosenv.2003.09.005>

- [8] How pollution, insects are threatening Taj Mahal, and what Supreme Court has said.” *The Indian Express*. (2022, September 27). Retrieved from <https://indianexpress.com/article/explained/explained-climate/how-pollution-insects-are-threatening-taj-mahal-and-what-supreme-court-has-said-8176610/> The Indian Express
- [9] India Today. (2024, November 14). *Air quality monitoring in Agra: hotspots near heritage sites*. <https://www.indiatoday.in/cities/agra/story/agra-air-quality-monitoring-data-2633492-2024-11-14>
- [10] Kumar, P., & Jain, S. (2010). Traffic induced noise and air pollution in Indian cities: Problems and perspectives. *Environmental Monitoring and Assessment*, 163(1–4), 493–501. <https://doi.org/10.1007/s10661-009-0857-x>
- [11] Kumar, R. (2020). An empirical study towards air pollution control in Agra, India. *SN Applied Sciences*, 2, Article 1845. <https://doi.org/10.1007/s42452-020-03826-4>
- [12] Kushwaha, D., et al. (2025). Estimating health and economic burden of PM₁₀ pollution in Agra, India. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-09137-1>
- [13] Lal, P., Tiwari, S., & Srivastava, A. K. (2020). Particulate matter characterization and its impact on the Taj Mahal. *Environmental Science and Pollution Research*, 27(25), 31745–31756. <https://doi.org/10.1007/s11356-020-09255-7>
- [14] Maji, K. J., Soni, P., & Ghosh, S. (2017). Assessment of city level human health impact and corresponding monetary cost burden due to air pollution in Agra, India. *Aerosol and Air Quality Research*, 17(8), 2018–2028. <https://doi.org/10.4209/aaqr.2016.02.0067>
- [15] Mandal, T. K., & Saxena, M. (2002). Characterization of PM₁₀ aerosols in Agra, India. *Environmental Monitoring and Assessment*, 79(3), 195–209. <https://doi.org/10.1023/A:1020217605575>
- [16] Mishra, D., & Shukla, J. P. (2015). Air quality deterioration in Agra: A threat to Taj Mahal. *Indian Journal of Environmental Protection*, 35(6), 495–502.
- [17] Multi-pollutant air quality analyses and apportionment of PM_{2.5}, PM₁₀, TSP and their chemical composition at the Taj Mahal (Agra). (2021). *Atmospheric Pollution Research*, 12(5), 1011–1020. <https://doi.org/10.1016/j.apr.2021.03.010>
- [18] Nagpure, A. S., Sahu, S. K., & Kumar, R. (2016). Emission inventory and source apportionment of air pollutants in Agra, India. *Environmental Science and Pollution Research*, 23(24), 24782–24795. <https://doi.org/10.1007/s11356-016-7582-3>
- [19] Pachauri, R. K., Singh, V., & Dubey, S. (2025). Air pollution in Agra: ARIMA-based forecasting and its health implications. *International Advanced Research Journal in Science, Engineering and Technology*, 12(8). <https://doi.org/10.17148/IARJSET.2025.12806>
- [20] Petrol, diesel vehicles have been banned within 500 metre of Taj Mahal: Union minister.” *The Economic Times*. (2017, July 20). Retrieved from <https://auto.economictimes.indiatimes.com/news/industry/petrol-diesel-vehicles-have-been-banned-within-500-metre-of-taj-mahal-union-minister/59675708> ETAuto.com
- [21] Ravindra, K., Wauters, E., Tyagi, S. K., Mor, S., & Van Grieken, R. (2006). Assessment of air quality after the implementation of compressed natural gas (CNG) as fuel in public transport in Delhi, India. *Environmental Monitoring and Assessment*, 115(1–3), 405–417. <https://doi.org/10.1007/s10661-006-7051-5>
- [22] SAFAR. (2023). *System of Air Quality and Weather Forecasting and Research*. Ministry of Earth Sciences, India. <https://sifar.tropmet.res.in/>
- [23] Sharma, A., & Roy, R. (2021). Impact of vehicular emissions on urban air quality in India: Policy challenges and future directions. *Journal of Environmental Management*, 285, 112132. <https://doi.org/10.1016/j.jenvman.2021.112132>
- [24] Social Impact Assessment Study for Agra Metro Rail Project. (2023). *Uttar Pradesh Metro Rail Corporation (UPMRC)*. Retrieved from <https://www.eib.org/attachments/registers/182740068.pdf>
- [25] SwachhIndia / NDTV. (2018, July 25). Polluting vehicles to be restricted in Taj Trapezium Zone. *NDTV*. Retrieved from <https://swachhindia.ndtv.com/air-pollution-polluting-vehicles-to-be-restricted-taj-mahal-23229/> NDTV-Dettol Banega Swasth Swachh India
- [26] Taneja, A., & Mishra, S. (2019). Air pollution and heritage conservation: The case of Taj Mahal, Agra. *International Journal of Environmental Science and Technology*, 16(11), 7163–7174. <https://doi.org/10.1007/s13762-018-2136-4>
- [27] Times of India. (2023, December 15). *Agra smog hides Taj Mahal during peak tourist season*. <https://timesofindia.indiatimes.com/city/agra/taj-mahal-hidden-by-smog-agra/articleshow/114661832.cms>
- [28] Tiwari, R., Singh, P., & Taneja, A. (2022). Chemical characterization of particulate matter at traffic-prone roadside environments in Agra, India. *Environmental Science and Pollution Research*, 29(5), 6905–6917. <https://doi.org/10.1007/s11356-021-17079-6>
- [29] Tiwari, R., Singh, P., & Taneja, A. (2023). Chemical fraction and health effect of size-

-
- segregated PM at national highways of northern India. *Pollution*, 9(4), 1895–1913. <https://doi.org/10.22059/poll.2023.360350.1946>
- [30] Tiwari, R., Singh, P., & Taneja, A. (2023). Morphology and health risk assessment of potential toxic metals in size-segregated particulate matter at a traffic location in Agra city. *Atmospheric Pollution Research*, 4(1), 200197. <https://doi.org/10.1016/j.apr.2023.200197>
- [31] WHO (World Health Organization). (2021). *WHO global air quality guidelines: Particulate matter (PM_{2.5} and PM₁₀), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. Geneva: WHO. Retrieved from <https://www.who.int/publications/i/item/9789240034228>