Literature Review

Urban air pollution remains a pressing issue shaped by multiple interacting systems. This review synthesizes insights from 14 peer-reviewed studies into three broad thematic areas: (1) Emission Sources and Exposure Pathways, (2) Urban Environment and Mobility Interactions, and (3) Monitoring, Forecasting, and Policy Tools. These categories reflect an integrative approach necessary to understand and mitigate the multifactorial nature of air pollution.

1. Emission Sources and Exposure Pathways

Pollutant concentrations in urban environments stem from a combination of localized and regional emissions. Dong et al. (2020) combined air dispersion models with GIS to highlight vehicle emissions as primary contributors to SO₂ exposure in China ([Dong et al., 2020](<https://doi.org/10.1038/s41598-019-57385-9>)). Chauhan et al. (2024) quantified black carbon (BC) in Varanasi, identifying fossil fuels as dominant sources, with seasonal modulation by meteorology and biomass burning ([Chauhan et al., 2024](<https://doi.org/10.1016/j.apr.2024.102061>)).

Amritha et al. (2024) used satellite and reanalysis data to reveal a global decline in SO₂ emissions during the COVID-19 lockdown, particularly in high coal-use regions, underscoring the anthropogenic nature of major SO₂ hotspots ([Amritha et al., 2024](<https://doi.org/10.1016/j.glt.2024.06.003>)). Obiefuna et al. (2021) mapped pollutant variability across land-use types in Nigeria, emphasizing the impact of urban planning on exposure patterns ([Obiefuna et al., 2021](<http://www.hrpub.org/download/20211230/EER9-13925304.pdf>)).

Complementing these, a clustering analysis of multi-point in situ data identified distinct pollutant dispersion patterns and emphasized long-range transport effects ([s10661-025-13927-5](<https://doi.org/10.1007/s10661-025-13927-5>)).

2. Urban Environment and Mobility Interactions

Urban mobility and spatial configuration play pivotal roles in shaping air quality. Ghaffarpasand et al. (2024) demonstrated the influence of traffic on PM2.5 levels in Kampala, with roadside locations showing a sharper response to mobility restrictions ([Ghaffarpasand et al., 2024](<https://doi.org/10.1016/j.apr.2024.102057>)). During the COVID-19 lockdown, Brunelli et al. (2021) observed temporary improvements in air quality, advocating for structural changes like low-emission transport and congestion charges ([Brunelli et al., 2021](<https://www.mdpi.com/1996-1073/14/17/5729>)).

From an infrastructural perspective, Mei et al. (2019) modeled pollutant retention in street canyons, showing how thermal flows and skyline shapes influence vertical ventilation and accumulation ([Mei et al., 2019](<https://doi.org/10.1016/j.buildenv.2018.12.050>)). Similarly, a study on street cleaning activities revealed brief increases in particulate resuspension, but highlighted how proper timing can mitigate exposure ([Brunelli et al., 2023](<https://doi.org/10.1016/j.apr.2023.101680>)).

Traffic-induced noise and pollution exposure modeling by Kephalopoulos et al. (2016) demonstrated the benefit of integrating flow dynamics with environmental risk assessment tools ([Kephalopoulos et al., 2016](<https://doi.org/10.1016/j.envpol.2016.07.031>)).

3. Monitoring, Forecasting, and Policy Tools

Technological advances are reshaping air pollution monitoring and forecasting. Singh et al. (2021) showcased how mobile sensors and machine learning can produce high-resolution pollution maps for urban interventions ([Singh et al., 2021](<https://www.frontiersin.org/articles/10.3389/fbuil.2021.648620/full>)). Sadeghi et al. (2023) extended this with a smart city framework that leverages IoT and citizen-sensing to integrate environmental and mobility data ([Sadeghi et al., 2023](<https://www.mdpi.com/1999-5903/15/9/263>)).

Forecasting studies like Tang et al. (2024) used hybrid machine learning models to nowcast ozone concentrations in East Asia with improved precision, especially under complex meteorological conditions ([Tang et al., 2024](<https://www.mdpi.com/2073-4433/15/5/699>)). These tools offer real-time insights critical for short-term health advisories and long-term planning.

This review demonstrates the importance of a systems-oriented perspective in urban air quality management. Emission source profiling, mobility dynamics, urban design, and smart monitoring must coalesce into comprehensive strategies. Each thematic area contributes unique tools and insights, but their synergy is essential to reduce urban air pollution sustainably.

References

- [Assessment of equivalent black carbon variations and its source apportionment over Varanasi](<https://doi.org/10.1016/j.apr.2024.102061>)

- [Population based Air Pollution Exposure and its influence factors](<https://doi.org/10.1038/s41598-019-57385-9>)

- [Urban air pollutant mapping and tracing using multi‑points in situ measurements](<https://doi.org/10.1007/s10661-025-13927-5>)

- [Geospatial Assessment of Ambient Air Quality Footprints in Relation to Urban Landuses in Nigeria](<http://www.hrpub.org/download/20211230/EER9-13925304.pdf>)

- [The impact of urban mobility on air pollution in Kampala](<https://doi.org/10.1016/j.apr.2024.102057>)

- [Effects of Pandemic on Air Pollution and Sustainable Mobility Solutions](<https://www.mdpi.com/1996-1073/14/17/5729>)

- [Methods to improve traffic flow and noise exposure estimation](<https://doi.org/10.1016/j.envpol.2016.07.031>)

- [Airborne pollutant dilution inside the deep street canyons](<https://doi.org/10.1016/j.buildenv.2018.12.050>)

- [A methodology to assess a mobile urban street cleaning activity](<https://doi.org/10.1016/j.apr.2023.101680>)

- [Monitoring Air Pollution in Philadelphia using low-cost sensors](<https://www.frontiersin.org/articles/10.3389/fbuil.2021.648620/full>)

- [Citizen-sensing and smart city frameworks](<https://www.mdpi.com/1999-5903/15/9/263>)

- [Enhancing ozone nowcasting over East Asia](<https://www.mdpi.com/2073-4433/15/5/699>)

- [Hybrid model for real-time ozone forecasting](<https://www.mdpi.com/2073-4433/15/5/699>)

- [The COVID-19 lockdown induced changes of SO2 pollution](<https://doi.org/10.1016/j.glt.2024.06.003>)