

EVALUATION OF THE EFFECTIVENESS OF ROAD CLEANING MECHANISMS IN INDIAN CITIES

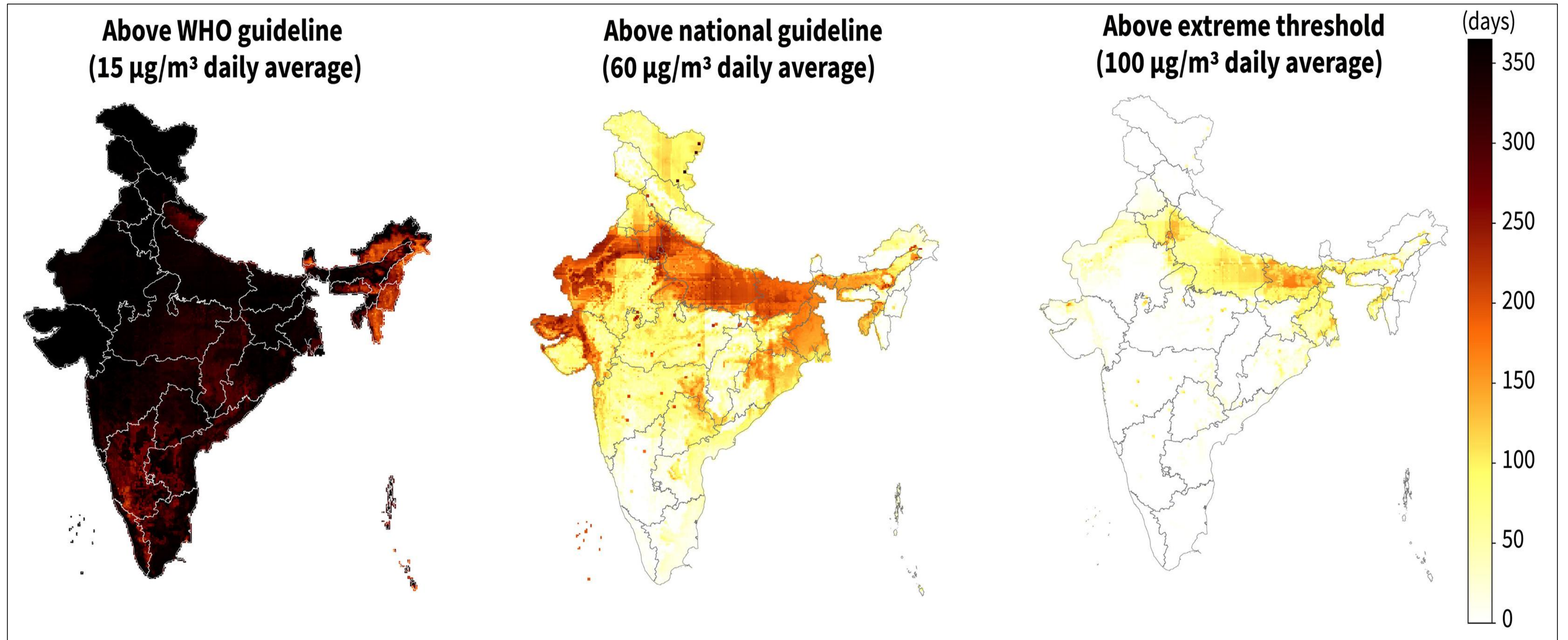
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Sreekanth Vakacherla et al.

Air pollution in India

- ~84% of India's population is exposed to annual average PM_{2.5} concentrations exceeding the national standard of 40 µg/m³ (Apte and Pant, 2019).
- Air pollution was associated with ~2 million premature deaths in India in 2023.
- In 2019, air pollution–related premature deaths and illness were estimated to cost India 1.36% of its GDP (Pandey et al., 2020).
- Major sources of PM pollution include industrial activities, transportation, and residential biomass burning (Kurmi et al., 2024).
- Under-researched sources, such as road dust, also contribute substantially, accounting for an estimated 30–60% of ambient PM₁₀ and PM_{2.5} levels (Ghosh et al., 2023).

Daily PM_{2.5} exceedance



<https://www.science.org/doi/10.1126/sciadv.adq1071>

NCAP and road dust management

- India launched the National Clean Air Programme (NCAP) in 2019 to address rising air pollution levels and identified 130+ non-attainment cities.
- The programme initially targeted a 20–30% reduction in PM concentrations from the 2017 baseline. The PM₁₀ reduction target was later revised to 40%, with an extended implementation timeline (Ganguly et al., 2020; Lal and Nagpure, 2026).
- The programme encourages cities to implement city-specific and source-specific pollution-control measures.
- Road dust management accounted for nearly 63–68% of NCAP funding during 2023–2025 (CREA, 2026).
- Road cleaning in India is generally carried out through manual cleaning, mechanical cleaning, water-based cleaning, and, in some cities, vacuum-assisted sweeping.

Water-based, mechanical, & manual cleaning



Objectives

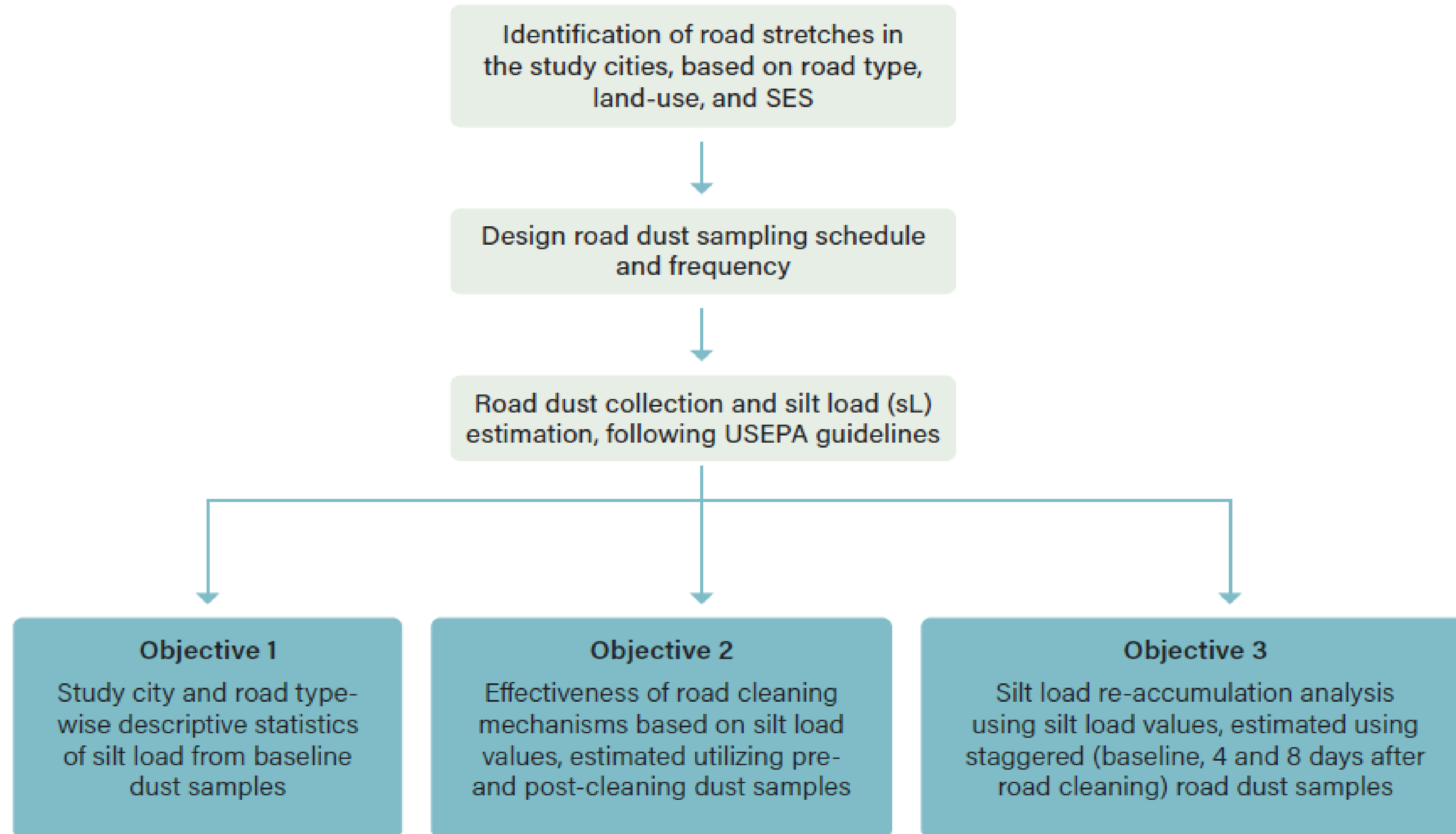
- To assess the effectiveness of wet and dry road-cleaning mechanisms adopted by the Mumbai city administration, and dry road-cleaning mechanisms in Indore.
- To investigate patterns of silt re-accumulation on roads in Mumbai and Ahmedabad.

Study cities



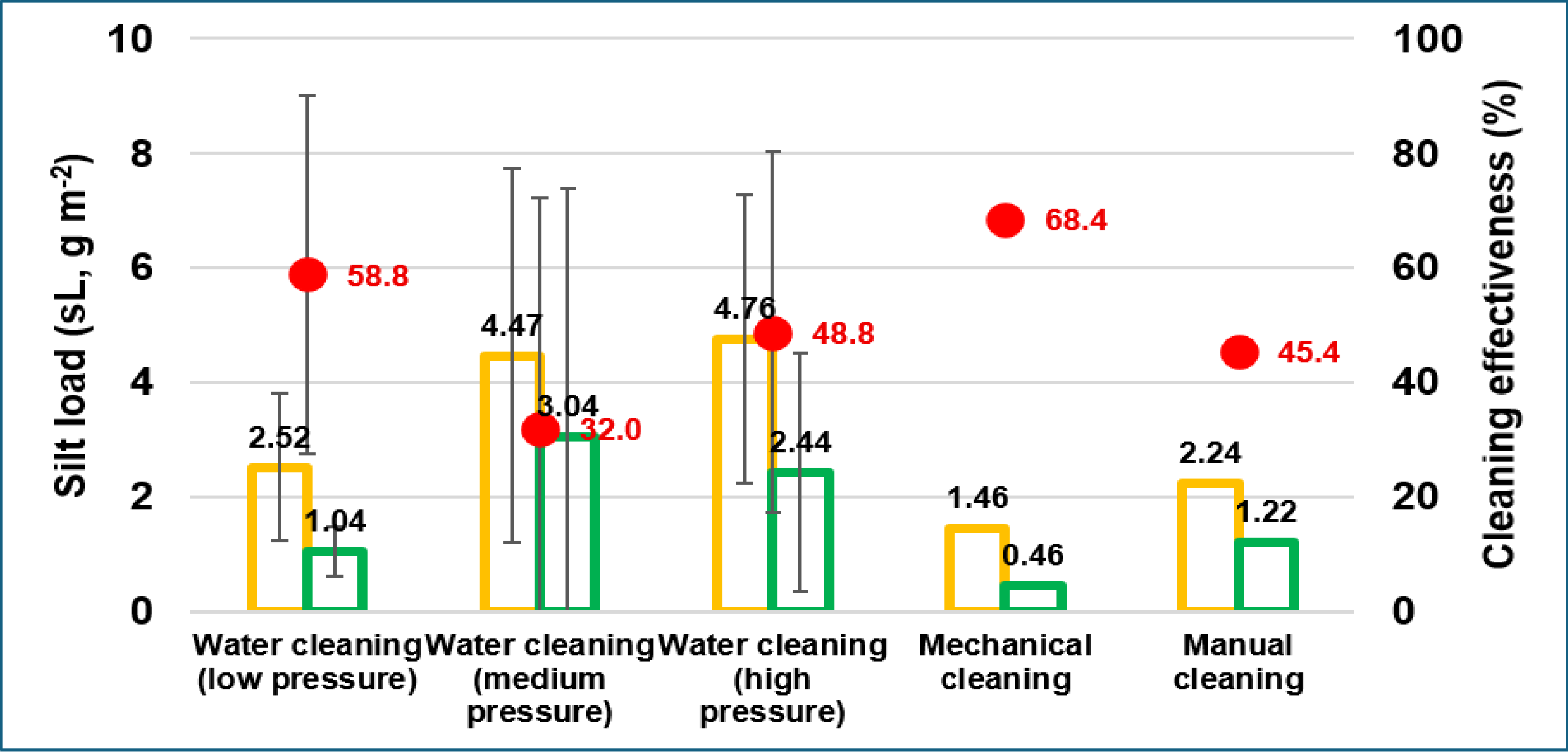
Parameter	Mumbai	Indore	Ahmedabad
Location	Maharashtra, Western Coast	Madhya Pradesh, Central India	Gujarat, Western India
Area (km ²)	483	276	464
Population	~13 million	~2.7 million	~7.6 million
Road Network	~2,000 km	~2,260 km	~2,580 km

Methodology



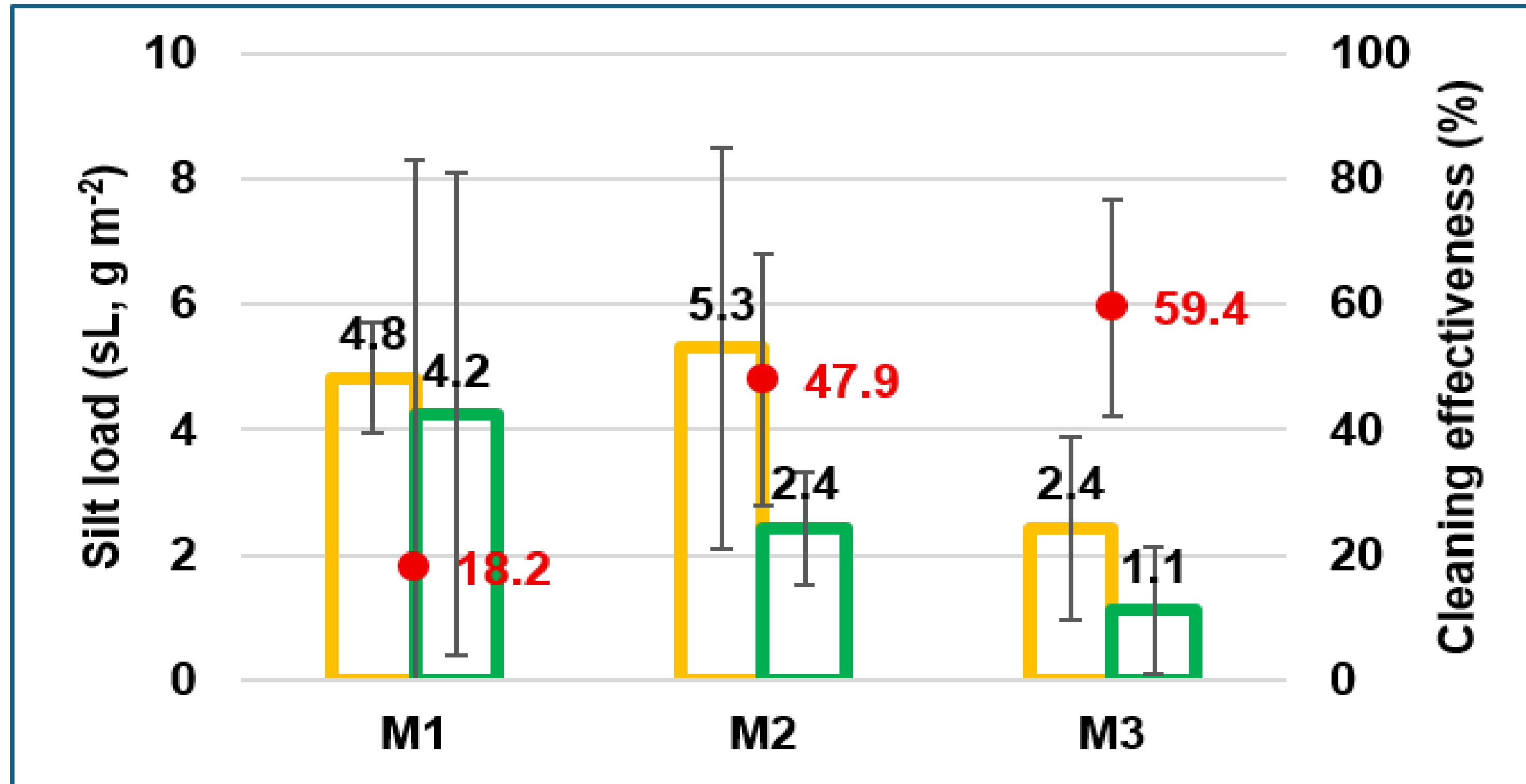


Road cleaning mechanism effectiveness: Mumbai



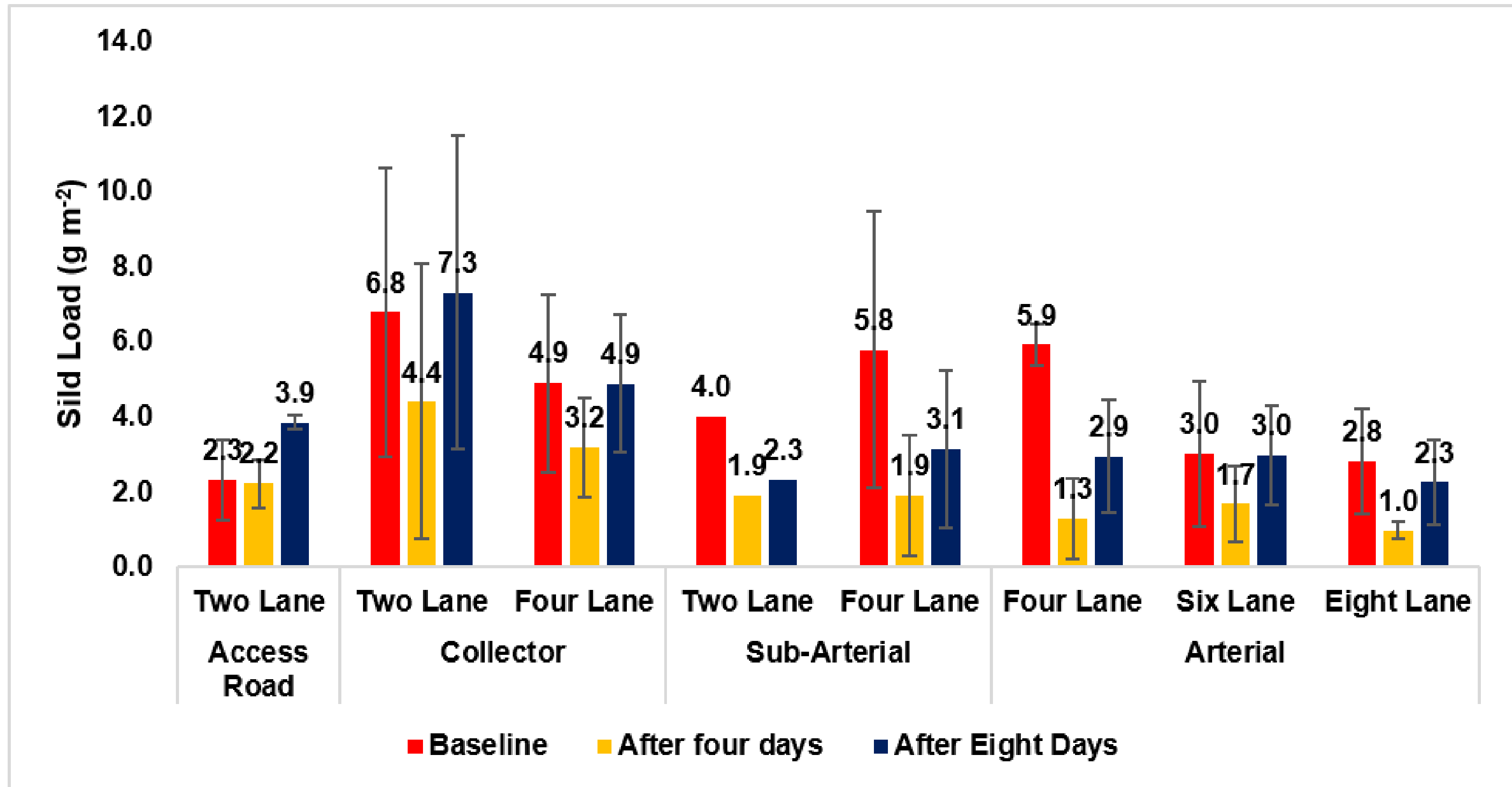
Pre-cleaning (yellow bar); post-cleaning (green bar) mean silt load, cleaning effectiveness (red dot).

Road cleaning mechanism effectiveness: Indore

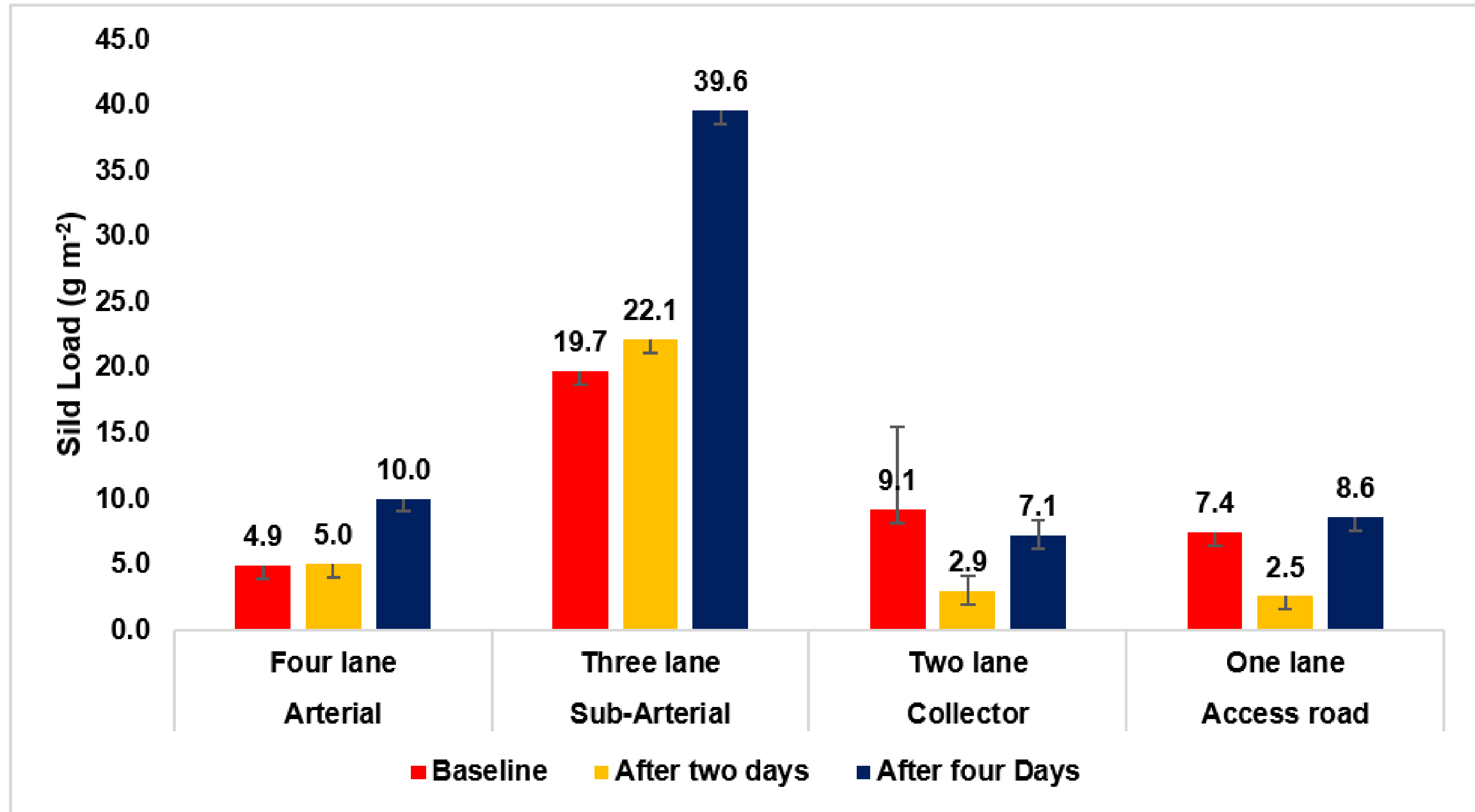


Pre-cleaning (**yellow bar**); post-cleaning (**green bar**) mean silt load, cleaning effectiveness (**red dot**).

Silt load re-accumulation: Mumbai



Silt load re-accumulation: Ahmedabad



Summary of results

- Silt loads vary by road type: Higher accumulation was observed on collector and sub-arterial roads, with values ranging from 1–20 g m⁻².
- Mechanical cleaning is most effective: Mechanical methods consistently reduced road dust more effectively than high- or medium-pressure water-based cleaning.
- Rapid reaccumulation: Silt loads returned to near pre-cleaning levels within 4–8 days, highlighting the need to optimize cleaning frequency and prioritize high reaccumulation roads.

Limitations

- Sampling periods, sample sizes, and road types varied across cities, limiting direct comparability.
- Data collected during different months were combined, with seasonal variability in silt load assumed to be negligible.
- Cleaning effectiveness was assessed only in Mumbai and Indore, while re-accumulation was assessed only in Mumbai and Ahmedabad, with only two post-cleaning time points.
- Small sample sizes limited statistical significance and prevented robust assessment by SES, land use, and source contributions.

Recommendations & Way Forward

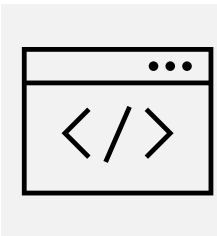
- Investigate the drivers of silt accumulation, including heavy traffic and other pollution sources.
- Conduct chemical speciation of road-dust silt to characterize its composition and identify potential sources.
- Undertake source apportionment using larger sample sizes to quantify the contributions of major sources to silt load.
- Translate source insights into proactive road-dust management and targeted mitigation measures.
- WRI India's ongoing study: Conducting exploratory chemical analysis of road silt samples collected from Mumbai.

References

1. Apte, Joshua S., and Pallavi Pant. 2019. “Toward Cleaner Air for a Billion Indians.” *Proceedings of the National Academy of Sciences* 116 (22): 10614–16. <https://doi.org/10.1073/pnas.1905458116>.
2. Kurmi, Om P., Tara Ballav Adhikari, Sudhir K. Tyagi, Per Kallestrup, and Torben Sigsgaard. 2024. “Addressing Air Pollution in India: Innovative Strategies for Sustainable Solutions.” *The Indian Journal of Medical Research* 160 (1): 1. https://doi.org/10.25259/IJMR_691_2024.
3. Pandey, Anamika, Michael Brauer, Maureen L. Cropper, Kalpana Balakrishnan, Prashant Mathur, Sagnik Dey, Burak Turkgulu, et al. 2021. “Health and Economic Impact of Air Pollution in the States of India: The Global Burden of Disease Study 2019.” *The Lancet Planetary Health* 5 (1): e25–e38. [https://doi.org/10.1016/S2542-5196\(20\)30298-9](https://doi.org/10.1016/S2542-5196(20)30298-9).
4. Ghosh, Abhinandan, Pavan Kumar Nagar, Brajesh Singh, Mukesh Sharma, and Dharendra Singh. 2023. “Bottom-Up and Top-Down Approaches for Estimating Road Dust Emission and Correlating It with a Receptor Model Results over a Typical Urban Atmosphere of Indo Gangetic Plain.” *Science of the Total Environment* 904: 167363. <https://doi.org/10.1016/j.scitotenv.2023.167363>.
5. Ganguly, Tanushree, Kurinji L. Selvaraj, and Sarath K. Guttikunda. 2020. “National Clean Air Programme (NCAP) for Indian Cities: Review and Outlook of Clean Air Action Plans.” *Atmospheric Environment: X* 8: 100096. <https://doi.org/10.1016/j.aeaoa.2020.100096>.
6. CREA (Centre for Research on Energy and Clean Air). 2026. *Tracing the Hazy Air 2026 Progress Report on National Clean Air Programme (NCAP)*. <https://energyandcleanair.org/publication/2026-progress-report-on-national-clean-air-programme/>.
7. Lal, Raj M., and Ajay S. Nagpure. 2026. “Evaluation of India’s National Clean Air Program Performance and Potential Health Benefits.” *Environmental Science & Technology Letters*. <https://doi.org/10.1021/acs.estlett.5c01224>.

Thank You

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