

Dust Free Road: A Replicable Municipal Model for Road Dust Management and Urban Air Quality Improvement

Municipal Corporation of Delhi, Karol Bagh Zone

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ABSTRACT- Air pollution has become one of the most critical environmental and public health challenges in rapidly urbanizing cities, with **road dust emerging as a major contributor to particulate matter (PM₁₀ and PM_{2.5})**. In Delhi, continuous vehicular movement, construction activities, deteriorated road shoulders, and legacy waste deposits accelerate dust resuspension, significantly affecting ambient air quality. While regulatory measures have primarily focused on vehicular and industrial emissions, **scientific municipal road dust management** remains an underexplored yet highly effective strategy for reducing particulate pollution.

This paper presents the **Dust Free Delhi Initiative** implemented by the **Municipal Corporation of Delhi (MCD)** as an integrated municipal framework for urban dust mitigation, using **Karol Bagh Zone** as a case study. The initiative transformed conventional sanitation practices into a structured environmental management programme by integrating **mechanized road sweeping, manual kerb-edge cleaning, central verge maintenance, pressure washing, water sprinkling, construction and demolition (C&D) waste removal, and scientific legacy waste management**. A systematic planning approach, supported by field inspections, risk-based road prioritization, continuous monitoring, and interdepartmental coordination, ensured sustained implementation and measurable outcomes.

The campaign resulted in the scientific cleaning of over **122 km of road network**, removal of **228 MT of roadside dust**, clearance of **150 MT of garbage and debris**. These interventions reduced dust accumulation, minimized particulate resuspension, enhanced road hygiene, strengthened operational efficiency, and contributed to improved urban environmental conditions.

The study proposes the **Dust Free Delhi Model** as a replicable municipal framework that integrates engineering practices, environmental management and scientific sanitation to combat urban air pollution. **The findings demonstrate that proactive municipal dust management is a cost-effective and scalable strategy for improving urban air quality, while supporting the objectives of the National Clean Air Programme (NCAP), Swachh Bharat Mission (Urban) and the United Nations Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).**

By promoting cleaner roads, responsible waste management, source segregation and sustainable urban practices, the model contributes to healthier communities, cleaner cities and long-term environmental sustainability.

Key Words: Urban Air Pollution, Road Dust Management, PM₁₀, PM_{2.5}, Dust Free Delhi, Municipal Corporation of Delhi, Mechanized Road Sweeping, Legacy Waste Management etc.

1. INTRODUCTION

The quality of air in urban environments has become one of the defining indicators of sustainable development and public health. As cities continue to expand through rapid urbanization, increasing motorization, intensive construction activities, and rising population densities, the concentration of airborne particulate matter has reached alarming levels.

Among the various air pollutants, Particulate Matter (PM_{2.5} and PM₁₀) poses the greatest threat due to its adverse impacts on human health, environmental quality, and urban livability. While significant attention has been directed toward controlling emissions from industries and vehicles, road dust remains one of the largest yet most manageable sources of particulate pollution, highlighting the critical role of scientific municipal interventions in improving urban air quality.

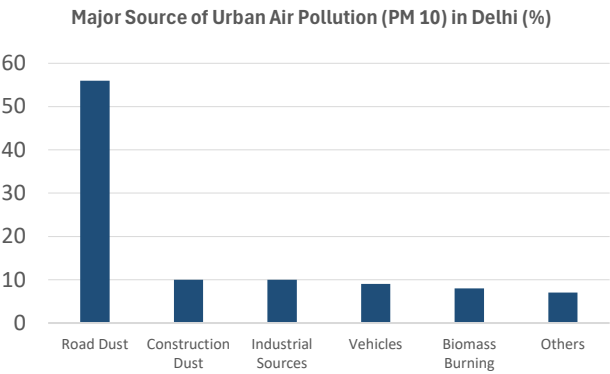
2. URBAN AIR POLLUTION IN DELHI

Delhi's air quality is influenced by a complex interaction of local emissions, regional pollution transport, rapid urbanization, and meteorological conditions. High traffic volumes, continuous infrastructure development, commercial activities, and dense population place significant pressure on the urban environment. These factors, combined with seasonal weather conditions that restrict pollutant dispersion, frequently result in elevated concentrations of particulate matter and poor air quality, particularly during the winter months. Among the various contributors to urban air pollution, road dust has emerged as one of the most significant locally manageable sources of particulate matter. The continuous deposition and resuspension of fine dust along roads, kerb edges, footpaths, and central verges increase ambient particulate concentrations and reduce the effectiveness of broader emission-control measures..

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Consequently, scientific municipal interventions aimed at controlling road dust have become an essential component of integrated urban air quality management



Source: Sharma, M. & Dikshit, O. (2016). Comprehensive Study on Air Pollution and Greenhouse Gases (GHGs) in Delhi. Indian Institute of Technology Kanpur. Submitted to the Department of Environment, Government of NCT of Delhi and Delhi Pollution Control Committee (DPCC). Published and cited in DPCC/CAQM documents (2018 onwards).

3. ROAD DUST AS A MAJOR SOURCE OF URBAN PARTICULATE POLLUTION

Road dust is widely recognized as one of the most significant and locally controllable sources of Particulate Matter (PM₁₀) in urban environments. Unlike emissions from industries or vehicles, road dust accumulates continuously on carriageways, kerb edges, footpaths, central verges, and road shoulders through the deposition of soil particles, construction and demolition (C&D) waste, vehicular tyre and brake wear, loose construction materials, roadside vegetation, and legacy waste. In densely populated metropolitan areas such as Delhi, these dust deposits are further aggravated by intensive construction activities, inadequate roadside maintenance, and high traffic volumes. Drive of c& d waste and chalaan of c&d.

The accumulated dust is continuously re-suspended into the atmosphere due to vehicular movement, tyre friction, wind turbulence, and human activities, resulting in elevated concentrations of coarse particulate matter (PM₁₀). This process not only deteriorates ambient air quality but also increases public exposure to airborne particulates, particularly along major roads, commercial corridors, and traffic intersections. Since road dust is generated and deposited at ground level, it can be effectively controlled through scientific municipal interventions such as mechanized road sweeping, manual kerb-edge cleaning, water sprinkling, pressure washing, proper management of construction and demolition waste, and timely removal of legacy waste. Therefore, systematic road dust management has emerged as a critical component of integrated urban air

pollution control and sustainable environmental management.

4. LIMITATIONS OF EXISTING DUST CONTROL MEASURES

Existing air pollution control measures have largely focused on emissions from vehicles, industries, thermal power plants, and open burning, while road dust management has received comparatively less attention. Conventional sweeping primarily removes visible waste but often leaves behind fine dust particles that are easily re-suspended by traffic and wind. This highlights the need for scientific dust mitigation practices, including mechanized sweeping, water sprinkling, pressure washing, and continuous monitoring, to effectively reduce road dust and improve urban air quality.

5. ROLE OF THE MUNICIPAL CORPORATION OF DELHI IN URBAN AIR QUALITY MANAGEMENT

The Municipal Corporation of Delhi (MCD) is one of the largest urban local bodies in the world, responsible for providing essential civic services across a major part of the National Capital Territory of Delhi. Its responsibilities extend beyond conventional municipal functions and include road maintenance, sanitation, solid waste management, Construction and Demolition (C&D) waste management, horticulture, storm-water drain maintenance, and environmental management. As the primary agency responsible for maintaining urban infrastructure and public spaces, the MCD plays a crucial role in controlling road dust by ensuring the scientific management of construction debris, preventing illegal dumping, and maintaining clean road corridors, thereby addressing one of the largest locally manageable sources of particulate pollution.

Recognizing the significant contribution of construction debris and road dust to urban air pollution, the MCD integrated Construction and Demolition (C&D) Waste Management as a core component of the Dust Free Delhi Initiative. The initiative combines scientific sanitation with dedicated C&D waste management through the establishment of designated C&D Waste Collection Centres, timely collection and transportation of construction debris, mechanized removal of illegally dumped waste, recycling at authorized processing facilities, and continuous field monitoring. These interventions are complemented by mechanized road sweeping, manual kerb-edge cleaning, water sprinkling, pressure washing, central verge maintenance, legacy waste removal, and enforcement against unauthorized dumping, thereby minimizing dust generation and preventing the resuspension of particulate matter.

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Unlike conventional debris clearance operations, the Dust Free Delhi-C&D Waste Management Framework adopts engineering-based planning, designated collection centres, scientific waste processing, regulatory enforcement, digital monitoring, and interdepartmental coordination. By ensuring that C&D waste is collected, recycled, and diverted from unauthorized dumping, the initiative reduces road dust emissions, conserves natural resources, and promotes a circular economy. The study evaluates this integrated municipal framework as a replicable model for sustainable C&D waste management, urban dust control, and improved air quality, supporting the objectives of the National Clean Air Programme (NCAP), Swachh Bharat Mission (Urban), and the United Nations Sustainable Development Goals (SDGs).

6. DUST FREE DELHI INITIATIVE: SCIENTIFIC ROAD DUST MANAGEMENT IN KAROL BAGH ZONE

To mitigate road dust and improve urban air quality, the Karol Bagh Zone of the Municipal Corporation of Delhi (MCD) implemented the **Dust Free Delhi Initiative**, a **41-day road dust mitigation campaign** covering all major Public Works Department (PWD) roads exceeding **60 feet in width**, comprising wide multi-lane arterial roads with central verges, footpaths, and kerb edges. The initiative adopted a scientific and systematic approach to achieve sustained **"No Dust"** status through mechanized cleaning, engineering interventions, periodic maintenance, and continuous field monitoring. Unlike conventional sanitation drives focused on visible cleanliness, the campaign emphasized preventive, source-based dust control and was implemented under a dedicated **Standard Operating Procedure (SOP)** to ensure uniform planning, execution, supervision, and monitoring across the zone. The SOP served as the foundation of the initiative by establishing a standardized operational framework for every stage of the campaign. It clearly defined the roles and responsibilities of Junior Engineers, Sanitary Inspectors/Sanitation Superintendents, Sanitation Guards, sanitation workers, and operators of mechanized equipment, ensuring accountability and coordinated execution at every level. The SOP prescribed a systematic sequence of activities beginning with the identification and prioritization of roads, deployment of manpower and machinery, mechanized sweeping, manual cleaning of kerb edges, footpaths, central verges, and inaccessible areas, scientific lifting and transportation of collected dust and debris, followed by water sprinkling, pressure washing, quality inspection, and periodic maintenance. It also laid down detailed inspection protocols, quality control measures, documentation requirements, monitoring mechanisms, and an eight-day maintenance cycle to sustain dust-free conditions and prevent re-accumulation, thereby transforming routine

road cleaning into a structured, evidence-based municipal dust management system.

The campaign followed a corridor-based implementation strategy, under which all major arterial and sub-arterial roads were identified and prioritized based on traffic intensity, commercial importance, and visible dust accumulation. Dedicated sanitation squads comprising Junior Engineers, Sanitary Inspectors/Sanitation Superintendents, Sanitation Guards, sanitation workers, and Mechanized Road Sweeper (MRS) operators were deployed under the supervision of designated field officers. The operational methodology consisted of mechanized sweeping of both carriageways, followed by manual removal of residual dust, silt, and debris from kerb edges, road shoulders, footpaths, bell mouths, and central verges. The collected dust and malba were scientifically lifted and transported to designated disposal facilities, after which water sprinkling and pressure washing were undertaken to suppress fine particulate matter. Each cleaned road stretch was inspected by the Ward Junior Engineer and Sanitary Inspector to ensure compliance with the prescribed **"No Dust"** standard, and the complete dust mitigation cycle was repeated every eight days to maintain sustained cleanliness and prevent dust re-accumulation.

The implementation of the Dust Free Delhi Initiative resulted in significant operational achievements. During the **41-day campaign**, approximately **122 km** of major road network was scientifically cleaned, **228 metric tonnes** of roadside dust were removed, and **150 metric tonnes** of garbage and debris were cleared from central verges through systematic field operations.

Continuous deployment of mechanized sweepers, sanitation manpower, water sprinklers, and supervisory teams ensured uniform implementation of the initiative across all identified road corridors. The dedicated Standard Operating Procedure (SOP) prescribed a scientific sequence of dust mitigation activities, including mechanized sweeping, kerb-edge cleaning, water sprinkling, pressure washing, C&D waste removal, legacy waste clearance, regular inspections, and continuous monitoring. It also defined operational responsibilities, inspection standards, and preventive maintenance schedules, ensuring consistency and accountability throughout the campaign. By integrating engineering practices, mechanization, standardized operating procedures, and evidence-based monitoring, the Dust Free Delhi Initiative established a practical and replicable model for reducing road dust, mitigating particulate pollution, and improving urban air quality.

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7. METHODOLOGY OF THE DUST FREE DELHI INITIATIVE

Step	Methodology	Key Activities
Step 1	Identification of Road Corridors	Identification and prioritization of major PWD roads based on traffic intensity, commercial importance, and visible dust accumulation. Deployment of dedicated sanitation squads comprising JE, SI/SS, SG, sanitation workers, and MRS operators.
Step 2	Mechanized Road Sweeping	Deployment of Mechanized Road Sweeper (MRS) machines on both carriageways for removal of loose dust, fine particulate matter, and roadside debris from road surfaces and central verges.
Step 3	Manual Cleaning	Manual scraping and cleaning of kerb edges, road shoulders, footpaths, bell mouths, medians, and central verges using hand tools to remove residual dust, silt, and debris inaccessible to mechanized equipment.
Step 4	Collection & Disposal	Collection, lifting, and transportation of accumulated dust, malba, garbage, and debris to designated disposal facilities through approved waste transportation mechanisms.
Step 5	Dust Suppression	Water sprinkling and pressure washing of roads, kerb edges, footpaths, and central verges to suppress fine particulate matter and minimize dust resuspension.
Step 6	Inspection & Quality Assurance	Field inspection by Ward Junior Engineer and Sanitary Inspector to verify compliance with the prescribed "No Dust" standard and ensure quality of cleaning operations.
Step 7	Periodic Maintenance & Monitoring	Repeat of the complete cleaning cycle every 8 days, supported by continuous monitoring, supervision, and performance evaluation to maintain dust-free road conditions.



Implementation of the Dust Free Delhi Initiative on a major PWD road in Karol Bagh Zone, demonstrating scientific road dust mitigation through mechanized sweeping, manual cleaning, water sprinkling, and field supervision.

Performance Indicator	Achievement
Roads Covered	122 km
Campaign Duration	41 Days
Road Dust Removed	228 MT
Garbage & Debris Removed	150 MT
Water Sprinkling	Throughout campaign
MRS Deployment	Both carriageways
Monitoring	Daily inspections

8. IMPLEMENTATION OF THE DUST FREE DELHI INITIATIVE

Following the adoption of a scientific and systematic road dust management methodology, the Dust Free Delhi Initiative was implemented across the major PWD roads of Karol Bagh Zone through a coordinated municipal approach.

The campaign integrated mechanized road sweeping, manual cleaning of kerb edges, footpaths and central verges, removal of accumulated dust and debris, water sprinkling, pressure washing, and continuous field supervision to achieve and sustain dust-free road conditions.

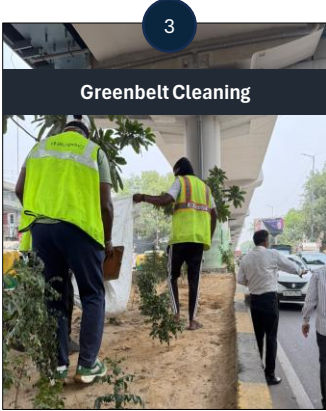
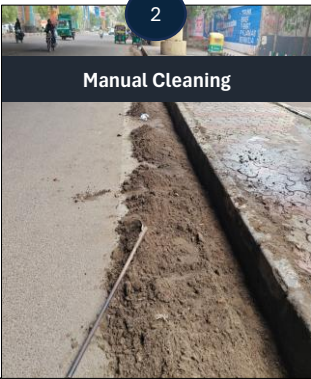
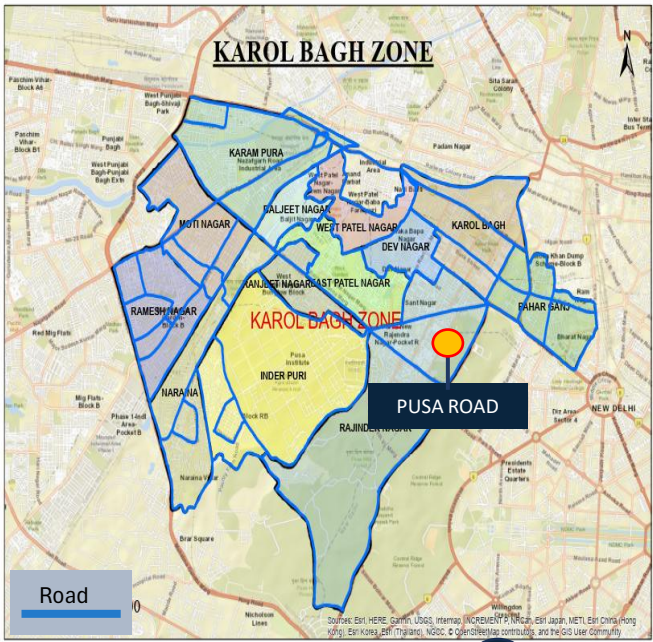
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The pictorial representation below illustrates the sequence of road dust mitigation activities undertaken during the campaign, while the accompanying performance summary presents the key operational achievements.

The initiative demonstrates that an integrated municipal approach combining engineering interventions, mechanized cleaning, and continuous monitoring can effectively reduce road dust accumulation and contribute to improved urban cleanliness and environmental quality.

Owing to the positive outcomes of the initial phase, the Dust Free Delhi Initiative was extended into a second phase to cover all connecting roads in Karol Bagh Zone. This phased implementation ensured comprehensive road coverage and sustained scientific road dust management throughout the campaign.



9. CONCLUSION

Urban road dust is one of the most significant and locally controllable contributors to particulate pollution in metropolitan cities such as Delhi. The findings of this study demonstrate that scientific municipal interventions, when implemented through a structured and integrated approach, can substantially improve road cleanliness and support urban air quality management. The Dust Free Delhi Initiative implemented by the Municipal Corporation of Delhi (MCD) in Karol Bagh Zone successfully transformed conventional road cleaning into a systematic dust mitigation programme by integrating mechanized road sweeping, manual kerb-edge cleaning, water sprinkling, pressure washing, continuous monitoring, and periodic maintenance.

The initiative demonstrated that coordinated planning, engineering interventions, and effective deployment of municipal resources can significantly reduce road dust accumulation and improve the overall urban environment. The successful implementation of the 41-day campaign, covering all major PWD roads in the zone, established a practical and evidence-based model for scientific road dust management.

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The operational methodology and implementation framework adopted under the initiative can serve as a replicable model for other urban local bodies seeking to strengthen municipal sanitation and contribute to air pollution mitigation.

With increasing urbanization and growing environmental challenges, road dust management should become an integral component of urban air quality strategies. The adoption of scientific cleaning methodologies, technology-enabled monitoring, data-driven planning, and regular maintenance can further enhance the effectiveness and sustainability of municipal dust mitigation programmes. The Dust Free Delhi Initiative demonstrates that proactive municipal governance can play a vital role in achieving cleaner roads, healthier urban environments, and more sustainable cities.

10.WAY FORWARD

Building upon the successful implementation of the Dust Free Delhi Initiative on major Public Works Department (PWD) roads exceeding 60 feet in width, the Karol Bagh Zone has initiated Phase II of the campaign to extend scientific road dust mitigation measures to all connecting roads, internal link roads, and roads measuring less than 60 feet in width. This expansion aims to ensure that the benefits achieved on major arterial corridors are sustained by addressing dust generation from adjoining road networks, which often serve as secondary sources of dust accumulation and recontamination.

The objective of Phase II is to establish a seamless and integrated dust management system across the entire road network of the zone by scientifically cleaning all interconnected roads through mechanized and manual interventions, periodic maintenance, and continuous field monitoring. The initiative is being implemented in a phased manner, ward by ward, with priority being accorded to roads experiencing high traffic movement, commercial activity, and significant dust accumulation. Similar to Phase I, all activities are being carried out in accordance with the established Standard Operating Procedure (SOP), ensuring uniformity in planning, execution, supervision, quality control, and monitoring.

The implementation of Phase II is presently under progress, with substantial work already completed in three wards of the Karol Bagh Zone. As on date, the following achievements have been recorded:

- Total Road Stretch Covered: 84 Kilometres
- Total Legacy Road Dust Removed: 226 Metric Tonnes
- Total Garbage and Debris Cleared from Central Verges: 121 Metric Tonnes

These achievements demonstrate the effectiveness of extending scientific dust mitigation practices beyond major arterial roads and highlight the positive impact of systematic cleaning and preventive maintenance on the overall urban environment. The remaining wards are being covered in a phased manner, and the campaign will continue until all connecting roads across the Karol Bagh Zone have been brought under the scientific dust management framework.

Going forward, the initiative will continue to strengthen institutional mechanisms for sustainable road dust management by ensuring regular mechanized sweeping, scheduled maintenance cycles, prompt removal of roadside dust and construction debris, and continuous monitoring of cleaned corridors to prevent dust re-accumulation. Greater emphasis will also be placed on integrating GIS-based road inventory and mapping, digital documentation of cleaned stretches, technology-enabled monitoring, geo-tagged photographic records, and performance-based evaluation of field teams to improve operational efficiency and accountability.

The Zone will continue to enhance interdepartmental coordination among Engineering, Sanitation, Horticulture, and field functionaries to ensure synchronized implementation of dust mitigation activities. Special attention will be given to vulnerable dust-generating locations such as intersections, commercial markets, construction zones, bus corridors, roadside parking areas, and road shoulders through targeted interventions and preventive maintenance.

Upon completion of Phase II, the Karol Bagh Zone will have established a comprehensive scientific road dust management system covering both major arterial roads and all connecting road networks. The initiative is expected to significantly improve urban cleanliness, reduce road dust generation, enhance air quality, strengthen public health outcomes, and create a sustainable and replicable model for scientific road dust mitigation that can be adopted by other zones of the Municipal Corporation of Delhi and urban local bodies across the country.

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