

Assessing Dust Pollution in Aurangabad: Environmental, Biological, and Human Health Implications Examined

Sachin R. Ahire¹, M.B. Mule²

^{1,2}Dr. Babasaheb Ambedkar Marathwada University Sambhajinagar University Campus, Maharashtra 431004, India

¹Email sach6262@gmail.com

Abstract

This research was undertaken in Aurangabad city to evaluate the effects of dust pollution on the environment and human well-being. Various locations were chosen to represent areas with high vehicle traffic, residential zones, industrial sites, and suburban regions, and the levels of respirable dust, including PM₁₀ and PM_{2.5}, were measured. The dust samples were tested for the presence of heavy metals and microorganisms, and the leaves of plants were inspected for dust buildup and visible signs of damage. Furthermore, a survey was carried out among local residents to determine the health issues associated with dust pollution. The Geographic Information System (GIS) was utilized to map the spatial distribution of dust pollution throughout the city. The findings showed that the concentrations of PM₁₀ and PM_{2.5} exceeded the National Ambient Air Quality Standards (NAAQS) at all locations, with the highest levels found in industrial and high-traffic areas. The concentrations of PM₁₀ ranged from 117 µg/m³ to 180 µg/m³, and those of PM_{2.5} ranged from 77 µg/m³ to 121 µg/m³, surpassing the NAAQS limits at all monitoring sites, with the highest levels recorded in industrial and high-traffic areas. A survey of 72 residents of Aurangabad revealed that dust pollution has a significant impact on health and daily life, with common complaints including respiratory difficulties (46%), hypertension (44%), skin issues (46%), and fatigue (69%). Many residents take protective measures, such as wearing masks (43%), and support public awareness campaigns (69%). Reducing the number of vehicles on the road (57%) was seen as a crucial step in controlling pollution. The main sources of dust pollution were identified as construction activities, vehicle emissions, unpaved roads, and industrial operations, emphasizing the need for targeted strategies to mitigate the effects and protect public health and the urban environment. Environmental concerns include dust and pollution, affecting human health and biology significantly.

1. INTRODUCTION

Deteriorating air quality is largely attributed to dust pollution, which originates from various sources including construction, road dust, industrial operations, and naturally occurring windblown particles. The rapid urbanization and industrialization of regions have led to dust pollution becoming a major environmental and public health concern (Bombay, 2024). The primary composition of dust pollution consists of fine particles emitted from construction sites, vehicle traffic on unpaved roads, mining activities, industrial procedures, and natural sources such as arid soil. This type of pollution elevates particulate matter levels, posing risks to human health, reducing visibility, and impacting ecosystems. To mitigate its effects, stricter regulations, enforcement, and dust-reduction strategies are necessary, along with the adoption of eco-friendly urban planning and increased public awareness. In numerous Indian cities, dust pollution accounts for a significant proportion of total particulate matter, particularly during dry periods when wind can easily pick up loose soil and debris (Shaikh, 2023).



Fig. 1 Dust Pollution

Dust pollution is characterized by the presence of mechanically generated particulate matter, comprising primarily coarse particles, including PM₁₀ and larger fractions, as well as a notable proportion of PM_{2.5}. This type of pollution arises from activities such as friction, construction, and soil disturbance, which are then re-suspended into the air due to turbulence caused by vehicles and wind (Collaborators, 2020). The particles that make up dust pollution are largely mechanically generated, consisting of materials like silica, alumina, and crustal minerals, as well as silt particles from worn road surfaces, construction and demolition debris, and resuspended particles. These particles are generated through processes including ground abrasion, tire wear, degradation of building materials, and soil erosion (Dubey et al., 2024).

Assessment of Airborne Particulate Matter in India:

Dust pollution in India is closely tied to urban planning, extending beyond construction activities alone. The impact of dust pollution is felt most severely in peri-urban and low-income areas, which often feature unpaved roads, exposed soil, brick kilns, and informal construction and transportation. This highlights that dust pollution is also a matter of equitable distribution and spatial justice, beyond just an environmental concern (Gawade et al., 2016).

In many Indian cities, the primary source of urban PM₁₀ pollution is dust resuspension. India is grappling with a severe environmental crisis due to dust pollution, which is exacerbated by construction, road dust, and industrial activities, resulting in approximately 1.5 to 2 million premature deaths each year. This has significant implications for public health, contributing to cardiovascular and respiratory diseases, as well as damaging vegetation and decreasing crop yields (Hanif, 2022). Road dust accounts for 20-52% of PM₁₀ and 8-25% of PM_{2.5}, largely due to the fragmentation of silt during transport. The silt load is particularly high in North Indian cities, ranging from 0.2-111 g/m², attributed to arid conditions, unpaved roads, and heavy traffic congestion (Iqbal et al., 2022).

A report by the Centre for Research on Energy and Clean Air, titled "Tracing the Hazy Air 2025", reveals that nearly 67% of the National Clean Air Program's funds have been dedicated to mitigating road dust. Data from the Central Pollution Control Board indicates that 21 cities participating in the program have seen a reduction of over 40% in PM₁₀ levels since 2017-2018. However, only 18 out of 131 cities meet the national air quality standard for PM₁₀, which is set at 60 µg/m³ (Irwe, 2017). A study conducted in India found that non-energy sources, particularly the resuspension of road dust, account for approximately 83% of PM₁₀ and 61% of PM_{2.5} pollution. Another study led by The Energy and Resources Institute in Kolkata and Howrah discovered that road dust is the primary contributor to PM₁₀ and PM_{2.5} pollution, at around 35% and 16% respectively. Furthermore, government data shows that 103 out of 130 cities have demonstrated an improvement in PM₁₀ levels, with 64 cities achieving a reduction of over 20% in the same period (Kalita, 2023).

Dust accumulation outpaces removal efforts in cities: The silt load on roads in many Indian cities exceeds the capacity of mechanical sweeping. Key dust-generating areas often fall outside municipal control, including unpaved stretches, dirt link roads, and village access roads in peri-urban areas, which constantly inject dust into urban centers. The design of roads themselves can create dust traps, with irregularities like uneven asphalt, potholes, unpaved sidewalks, and damaged medians capturing silt. A 2024 pilot study by the CAQM revealed that 24% of inspected roads were in poor condition, acting as persistent sources of dust (Kamble & Pandkar, 2021).

Construction and demolition activities often lack scientific management, with dust control measures at building sites being either superficial or sporadic. The construction zone of the Dwarka Expressway experienced PM₁₀ levels of 600-800 µg/m³ during piling and excavation, despite existing regulations. Northern India's soil, composed of fine alluvial silt, is prone to becoming airborne, especially during pre-monsoon periods of high wind from March to June, which enhances dispersion, as seen in Jaipur's 35-45% increase in PM₁₀ levels during the May 2023 dust storms (Kameswaran, 2019).

Assessment of Particulate Matter in Aurangabad:

Dust pollution has become a major environmental issue in Aurangabad, driven by factors such as rapid urban growth, rising vehicle numbers, construction work, and the presence of industrial areas. To assess dust pollution, the city conducts thorough monitoring of ambient dust levels in various areas, including residential, commercial, and industrial zones, to identify geographic patterns. Industrial areas receive particular focus, as they often exhibit higher dust levels resulting from industrial emissions and insufficient pollution controls. The amount of dust accumulating on plant surfaces is a reliable gauge of air quality, as it indicates the severity and persistence of particulate pollution (Shelke & Sadeque, 2017).

Examination of dust samples reveals heavy metal and microorganism contamination, posing ecological and health hazards. Long-term dust pollution exposure is linked to respiratory issues, allergic reactions, and other health concerns in the local community. Assessing dust pollution in Aurangabad is crucial for understanding its environmental effects and for creating effective solutions, such as utilizing vegetation to naturally reduce dust and enhance air quality (Bombay, 2024).

Annual averages for PM_{2.5} and PM₁₀ in Aurangabad for 2020 are not found in published reports, but regional data indicates that air quality declined in many Indian cities following the COVID-19 lockdown, attributed to the resumption of industrial and transportation activities. Historical data from 2019 reveals that Aurangabad's PM_{2.5} levels were already high, with an annual average of approximately 44.2 µg/m³, exceeding healthy thresholds prior to 2020 (Hanif, 2022).

Air quality assessments in Aurangabad have shown that PM_{2.5} and PM₁₀ levels in the ambient air often surpassed permissible limits in previous years, such as 2018, suggesting a long-standing problem that persisted up to 2022. Historical air quality comparisons reveal a substantial increase in Aurangabad's annual Air Quality Index by 2026, compared to preceding years like 2020 and 2021, signaling a decline in overall air quality due to the impact of PM_{2.5} and PM₁₀ (Kaushik et al., 2016).

The Maharashtra Pollution Control Board's draft air quality report from July 2024 revealed that particulate matter levels, including PM₁₀ and PM_{2.5}, frequently surpassed Indian standards at various locations in Aurangabad, with PM_{2.5} being of particular concern. The detailed data collected in 2024 paints a picture of heightened particulate matter in the city's air, attributing it to multiple factors such as road dust, construction activities, and industrial emissions. Air quality readings from late 2025 consistently place Aurangabad in the "poor" to "unhealthy" category, with notably high PM_{2.5} and PM₁₀ levels recorded on several occasions, including a winter day when PM_{2.5} reached approximately 85 µg/m³ and PM₁₀ reached around 91 µg/m³, underscoring the persistent issue of dust and particulate pollution (Kamble & Pandkar, 2021).

Effects of Dust Pollution on the Environment, Plant Life, and Humans:

Dust pollution, resulting from construction, mining, and wind erosion, substantially impairs air quality and ecosystem health by elevating particulate matter levels (PM₁₀, PM_{2.5}). This disrupts photosynthesis, alters soil and water chemistry, harms aquatic life, and decreases visibility, also posing significant risks to human health, including heart and respiratory issues (Kasulkar, 2024).

Dust accumulation on plants obstructs sunlight, hindering the processes of transpiration and respiration, which in turn decreases photosynthesis and leads to lower crop yields. This can also cause physical harm to plant tissues and disrupt the composition of plant communities. Dust particles in the air can travel extensive distances, transporting harmful substances such as toxic chemicals, metals, and nutrients like sulfates and nitrates, which can alter the pH levels of soil and water bodies (Kedia, 2018). Consequently, this can lead to the acidification of streams and lakes, impacting aquatic ecosystems. Dust storms, comprising sand and dust, directly contribute to air pollution, reducing visibility and potentially depleting ozone levels, while also modifying Earth's reflectivity and influencing local and global climate patterns. Similarly, animals are at risk of respiratory problems and habitat disruption due to the chemical makeup of deposited dust. Furthermore, dust particles can damage, corrode, and expedite the deterioration of structures, landmarks, and infrastructure (Khan, 2023).

Dust pollution from sources like roads and industrial activities has a profound impact on plant life. It coats foliage, obstructs sunlight, and clogs stomata, thereby impeding photosynthesis, respiration, and transpiration. This results in stunted growth, decreased crop yields, yellowing of leaves, tissue death, and disrupted reproductive cycles. The accumulation of dust on leaves hampers light absorption and gas exchange, leading to higher leaf temperatures and reduced photosynthetic activity, ultimately affecting carbohydrate production (A. Kumar et al., 2016).

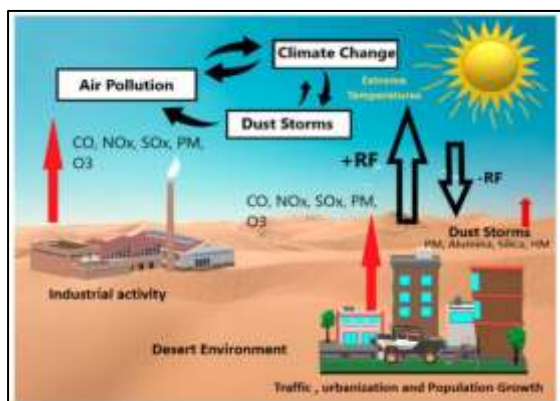


Fig. 2 Impacts of Dust Pollution on Environment

Dust, particularly when laden with alkaline substances or heavy metals, can induce tissue damage and necrosis in leaves, leading to stress that decreases chlorophyll levels and prompts premature leaf fall. Ongoing dust accumulation results in stunted plant growth, decreased leaf coverage, reduced biomass production, and lower reproductive output. Certain species, such as lichens and mosses, are especially vulnerable, disrupting the local plant community's composition. Furthermore, dust pollution contributes to elevated heavy metal levels in plant tissues, threatening the well-being of organisms that feed on them (R. Kumar et al., 2014).



Fig. 3 Impacts of Dust Pollution on Plants

Dust pollution, especially fine particulate matter, poses significant health risks by infiltrating the lungs and entering the bloodstream. This can lead to severe health issues, including cardiovascular diseases such as heart attacks and strokes, as well as respiratory problems like asthma, chronic obstructive pulmonary disease, and infections. Lung cancer and eye irritation are also potential consequences (Kumari & Jain, 2021). Certain groups, including children, the elderly, and individuals with pre-existing conditions, are more susceptible to these risks. Inhaling dust can cause immediate symptoms like coughing, wheezing, and chest discomfort, while prolonged exposure may result in chronic conditions like COPD, pneumonia, and impaired lung function. Dust is a known trigger for asthma attacks and can cause systemic inflammation, increasing the risk of hypertension, blood clots, and heart arrhythmias (Mahato & Singh, 2020). Long-term exposure to certain dust components has been linked to lung cancer, and may also have neurological effects, such as dementia, and contribute to adverse birth outcomes, including low birth weight. Additionally, dust particles can cause eye problems like conjunctivitis and irritation. Individuals with pre-existing lung or heart conditions, children, pregnant women, older adults, smokers, and those with low socioeconomic status are at a higher risk of experiencing these negative health effects (Maji et al., 2016).



Fig. 4 Impact of Dust Pollution on Human Health

Answer to reduce Air Contamination:

Mechanical road sweepers, equipped with high-efficiency vacuum technology, utilize suction nozzles, rotating brushes, and advanced filtration systems to collect re-suspended dust particles. This is significant, as road dust accounts for up to 56 percent of particulate matter in Indian metropolitan areas (Pandit & Sharma, 2020). A study by the Pollution Control Committee found that the introduction of over 100 vacuum sweepers in Delhi from 2022 to 2024 resulted in a 10-15 percent reduction in particulate matter along main roads. Additionally, anti-smog guns and water mist cannons have been effective in mitigating dust pollution by spraying fine mist droplets that bind with dust particles, causing them to settle, particularly in areas such as construction sites, mining zones, and high-traffic corridors (Shelke & Sadeque, 2017).

Vehicle-mounted dust suppression systems are installed on various municipal vehicles, including garbage trucks and road rollers, to emit a fine mist while in operation. In 2023, the Nagpur Municipal Corporation deployed mobile dust control units, resulting in a 20 percent reduction in visible dust on heavily trafficked roads. Eco-friendly dust consolidation agents, which utilize bio-enzymes, create a protective layer over loose soil, preventing re-suspension for 15-30 days. This technology is applied in areas such as mining sites, barren lands near highways, and construction debris storage. Notably, Coal India Limited's mining sites adopted bio-based binders in 2023, achieving a reduction of up to 40 percent in particulate levels within mine haul roads (Supe & Gawande, 2015).

2. Rationally of the Study

Aurangabad, a city experiencing rapid urbanization and industrial growth, is grappling with rising dust pollution, which has detrimental effects on both environmental quality and public well-being. To effectively address this issue, regular monitoring of dust levels is crucial, particularly in industrial areas, to determine particulate matter concentrations, pinpoint pollution sources, and track changes over time influenced by human activities and seasonal fluctuations. Utilizing plants to combat dust pollution is a viable approach, as they can naturally filter out particulate matter, improve air quality, and support urban greening initiatives. This research combines environmental monitoring, biological evaluation, toxicological assessment, health impact analysis, and ecological mitigation strategies to provide a thorough understanding of dust pollution in Aurangabad, ultimately informing data-driven policy decisions and urban planning.

3. LITERATURE REVIEW

Dust pollution is a significant environmental concern in urban and industrial areas, given its detrimental impact on ecosystems and human well-being. Research has shown that elevated particulate matter levels, especially in rapidly growing cities, are strongly linked to emissions from industrial sources, vehicle traffic, construction work, and the re-suspension of dust from roads. The importance of tracking ambient dust levels to evaluate air quality and pinpoint pollution sources has been highlighted in previous investigations. Overall, these findings establish a scientific basis for comprehending dust pollution, emphasizing the necessity for a multi-faceted approach that incorporates monitoring, impact evaluation, and sustainable mitigation strategies to address this issue.

A study by Stuti Dubey and colleagues, published in 2024, investigated the seasonal fluctuations in metal concentrations and associated health risks in school dust from Agra, India. The research involved digesting dust samples in aqua regia and then analyzing metal concentrations using ICP-AES. The findings showed that, across all seasons, roadside schools in both urban and rural areas had higher metal concentrations in settled dust compared to residential schools, with the exception of semi-urban schools during the post-monsoon season. The pollution load index values for all schools ranged from below one

to above one, indicating varying levels of metal pollution. Additionally, the geo-accumulation index revealed moderate to high contamination of school dust with cadmium across all seasons. The health risk assessment identified ingestion as the primary exposure route, followed by dermal and inhalation exposure. While the hazard index for all metals was below the safe threshold of one, the total cancer risk for lead exceeded safe limits via inhalation. The results highlight the need for further research into toxic metal contamination in Agra's schools, particularly for lead, cadmium, and chromium.

A recent study by Gayatri Kalita and colleagues (2023) highlights the effective deployment of an Air Quality Early Warning System (AQEWS) in predicting a severe dust storm that affected western India from January 21-24, 2022. The research reveals that the AQEWS's aerosol data assimilation process was instrumental in forecasting the unusual surge in PM₁₀ levels across several cities in western India, enhancing the initial conditions of PM₁₀ by around 24-40 µg/m³ and PM_{2.5} concentrations by approximately 30-38 µg/m³. Without this assimilation, the system was unable to accurately forecast the storm's intensity and variability. The mean bias of the 72-hour PM₁₀ prediction was significantly reduced with assimilation, dropping from -44% to 0.35% in Mumbai and from -57% to 13% in Gujarat. The AQEWS successfully captured the peak intensity and variability of the dust storm, as validated by on-site measurements in specific regions. These measurements confirmed that the AQEWS accurately predicted the storm's peak intensity and pattern. Overall, the AQEWS demonstrated enhanced forecasting capabilities for extreme dust events during winter, with chemical assimilation improving the accuracy of real-time air quality forecasts.

A study by Sahila Shaikh and colleagues in 2023 examined the effectiveness of chemical road dust suppressants on paved roads in Pimpri Chinchwad. The research focused on two seasons, winter and summer, and involved spraying three types of roads with varying traffic density and land-use categories. Samples were collected from a 1m² area using a portable vacuum cleaner, first on day one, and then after spraying with Calcium Chloride (CaCl₂) and Magnesium Chloride (MgCl₂). A second set of samples was collected 24 hours after the chemical application. The results showed a significant reduction in silt loading, with a maximum reduction of 99.73% achieved with 30 g/m² of CaCl₂. The emission factor of PM_{2.5} decreased by 97.78%, and PM₁₀ decreased by 97.59%. Additionally, the average particle size increased to 27.88 µm. Both suppressants effectively reduced road dust, but the results from day one showed greater dust suppression compared to day two. Furthermore, CaCl₂ was found to be a more effective dust suppressant than MgCl₂ based on dust loading.

A study by Mohamad Hanif and colleagues in 2022 assessed the air quality in Aurangabad, providing valuable insights for mitigating pollution. The findings reveal that the SBES college station has the highest levels of pollution and the poorest Air Quality Index among all tested stations. In contrast, the Waluj MIDC, C.A.D.A., and Collector Office stations exhibit lower air quality indices. The Air Quality Index results from each sampling station suggest a steady increase in air pollutants in Aurangabad, resulting in declining air quality. The air quality in these areas ranges from poor to very poor. This research may prompt individuals who are indifferent to air pollution to take notice and take action.

A study conducted by Qaiser Iqbal and colleagues in 2022 aimed to evaluate the air quality in regions with and without marble factories. The research focused on measuring the concentration of particulate matter, specifically total suspended particles (TSP). To collect data, the team utilized EPAM-5000 equipment to assess particulate levels. Additionally, a spectrophotometer was employed to examine the chemical composition of marble dust, including the presence of PM_{2.5} and PM₁₀. The results showed that TSP concentrations in the Darmangi and Malagori areas of Peshawar, Pakistan, where marble factories are present, were 626 µg/m³ and 5321 µg/m³, respectively. The corresponding PM_{2.5} and PM₁₀ concentrations in Darmangi were 189 µg/m³ and 520 µg/m³, while in Malagori, they were 195 µg/m³ and 631 µg/m³. These values exceeded the World Health Organization's recommended standards and were significantly higher than those in areas without marble factories. The findings suggest that regions with marble factories are more prone to air pollution due to elevated TSP concentrations. To mitigate this issue, it is suggested that marble factories be relocated away from residential areas, with strict regulations enforced. Furthermore, individuals should be advised to use protective gear, and waste management practices should be implemented, along with monitoring systems to control particulate levels.

A study conducted by Shweta Kumari and colleagues in 2021 investigated the levels of heavy metals in particulate matter (PM₁₀ and PM_{2.5}) and road dust along certain road networks in Dhanbad, India.

The research analyzed the sources of these heavy metals and evaluated the potential health risks they pose. The results showed that the average mass concentrations of PM₁₀ and PM_{2.5} were $229.54 \pm 118.40 \mu\text{g m}^{-3}$ and $129.73 \pm 61.74 \mu\text{g m}^{-3}$, respectively. Notably, the concentration of heavy metals was higher in PM_{2.5} than in PM₁₀. The pollution load index for both PM₁₀ and PM_{2.5} road dust indicated a deteriorating condition. The primary source of pollution was identified as vehicles. Although the non-carcinogenic effects on both children and adults were within acceptable limits, the heavy metals in PM and road dust still posed a health risk, with road dust being the most hazardous, followed by PM₁₀ and then PM_{2.5}. However, due to their smaller size, particulate matter posed a greater health risk than road dust. The analysis of mass concentrations revealed significant contamination of PM₁₀ and PM_{2.5} in the study area, primarily attributed to vehicle traffic, which was the major source of heavy metals in PM₁₀, PM_{2.5}, and road dust.

A study by Mukesh Kumar Mahato and colleagues, published in 2020, focused on the copper and iron mining regions of East and West Singhbhum districts in Jharkhand. The research had two primary objectives: to assess dust fall rates and to examine the mineral composition of atmospheric dust. These districts are among India's most industrialized areas, with significant copper and iron ore mining, steel production, power generation, and related activities. To enhance the living conditions of local residents, it is essential to establish a baseline for dust pollution and its characteristics through scientific research, which can inform policy decisions and their implementation. The findings showed that dust fall rates were higher during summer due to increased wind speeds, while lower rates were observed during winter because of monsoonal rainfall and higher humidity, which reduced dust resuspension. This study investigated the extent of dust fall rates and their mineral characteristics, highlighting the need for regular monitoring of dust pollution and the implementation of effective control measures, such as wet dust suppression and airborne dust capture, to mitigate dust pollution.

Researchers, including S. Kameswaran, et al. [2019], have examined the impact of dust pollution on vegetation parameters. Key sources of dust pollution encompass soil suspension, agricultural activities, road dust, vehicle emissions, power plants, construction, open fires, brick kilns, cement factories, and volcanic activity. This pollution leads to plant stress, characterized by stomatal closure, altered cellular structure, necrotic leaves, pigment degradation, and chlorosis. Upon dust deposition, the initial physiological response occurs in the leaves, resulting in decreased net assimilation efficiency. Prolonged exposure alters photochemical processes, hindering leaf growth. Long-term dust accumulation on plant surfaces significantly disrupts the assimilate balance. Furthermore, high wind speeds can exacerbate abrasive dust effects, increasing disease and pest susceptibility by physically removing the protective leaf cuticle. Dust deposition also alters soil chemistry in the rhizosphere, affecting soil nutrient levels and availability.

Researchers, including Sumita Kedia, investigated the effects of a dust storm on the Indian subcontinent and surrounding areas in 2018. Their findings indicate that the storm led to notable alterations in aerosol properties, including optical, physical, and radiative characteristics, due to the prevalence of coarse-mode aerosols in the atmosphere. An examination of particulate matter concentrations revealed that dust aerosols were present from the surface up to altitudes of 3-4 km during the storm. The dust storm caused a cooling effect at the surface by reducing shortwave radiation. A significant drop in temperature was also observed at 850 hPa, suggesting that the dust layer had a substantial impact on the atmospheric temperature profile. While dust aerosols caused atmospheric heating in the shortwave region, this effect was largely offset by the longwave cooling effect of the dust. The net radiative impact of the dust at the top of the atmosphere varied from -2.49 to -0.34 Wm^{-2} across different regions, and at the surface, it ranged from -0.62 to $+0.32 \text{ Wm}^{-2}$.

A study by Gajanan Shelke and colleagues in 2017 examined the levels of particulate matter and gaseous pollutants in Aurangabad City. The presence of these pollutants is a significant contributor to respiratory diseases and fatalities. Dust pollution is a pervasive issue in many Maharashtra cities. This research presents findings from ambient air quality monitoring in Aurangabad, focusing on particulate matter, sulphur dioxide, and nitrogen dioxide. The Modified West and Geake Method was used to measure sulphur dioxide, while nitrogen dioxide was assessed using the Modified Jacob and Hochheiser method. The results revealed high particulate matter concentrations, although sulphur dioxide and nitrogen dioxide levels were within acceptable limits.

A study by Geetanjali Kaushik et al. in 2016 focused on determining PM10 levels at various sites in Aurangabad. The results showed that the Railway Station had the highest PM10 concentration, followed by Waluj, an industrial area, and City Chowk, a densely populated central location with tall buildings and limited open spaces, leading to congestion and poor particulate dispersion. Other areas with high PM10 concentrations included Mill Corner, Harsul T-point, Kranti Chowk, Seven Hills, TV Centre, and Beed Bypass. These locations are characterized by narrow roads, heavy traffic, poor road conditions, and limited crossing points, resulting in congestion, idling vehicles, and high pollution levels. The findings highlight the severity of air pollution in the city, which may worsen if left unchecked. Consequently, implementing strategies to mitigate air pollution is essential to address this issue.

Table 1 Comparative Study on Previous Work Done

Author / Year	Key Results / Findings	Research Gap Identified
Stuti Dubey et al., 2024	Seasonal variation in metal concentration observed in school dust of Agra. Roadside schools showed higher metal accumulation than residential schools. Cd contamination ranged from moderate to heavy in all seasons. Ingestion was the major exposure route. Pb showed higher cancer risk via inhalation beyond safe limits.	Limited spatial coverage and lack of long-term monitoring. Need for detailed investigations focusing on Pb, Cd, and Cr contamination in school environments and mitigation strategies.
Gayatri Kalita et al., 2023	AQEWS successfully forecasted an extreme dust storm event in western India. Aerosol data assimilation significantly improved PM10 and PM2.5 prediction accuracy. Mean bias reduced substantially with assimilation.	Study focused on a single extreme event. Long-term performance evaluation of AQEWS under different meteorological conditions and urban settings is required.
Sahila Shaikh et al., 2023	Chemical dust suppressants (CaCl ₂ and MgCl ₂) effectively reduced silt loading and PM emissions. CaCl ₂ showed higher efficiency with up to 99.73% reduction. Effectiveness declined after 24 hours.	Long-term environmental impacts and cost-effectiveness of repeated chemical application were not evaluated. Seasonal variability beyond winter and summer remains unexplored.
Mohamad Hanif et al., 2022	AQI analysis revealed poor to very poor air quality in Aurangabad. SBES College station was the most polluted. Increasing pollutant trends observed across stations.	Lack of source apportionment and absence of health risk assessment. The study does not propose mitigation or policy-level interventions.
Qaiser Iqbal et al., 2022	Areas near marble factories showed extremely high TSP, PM10, and PM2.5 concentrations, exceeding WHO limits. Marble dust significantly deteriorated local air quality.	Chemical characterization and long-term health impact assessment were not conducted. Effectiveness of regulatory or engineering controls was not evaluated.
Shweta Kumari et al., 2021	High PM10 and PM2.5 concentrations in Dhanbad. Heavy metals were more concentrated in PM2.5. Vehicles were the dominant pollution source. Health risks were within acceptable limits but higher for road dust.	Study limited to selected road networks. Seasonal variability and mitigation measures for traffic-related dust pollution were not assessed.
Mukesh Kumar Mahato et al., 2020	Higher dust falls rates observed in summer due to wind dispersion. Mineralogical characterization confirmed industrial and	Health impacts of dust exposure were not evaluated. Absence of quantitative assessment of

	mining influence. Winter showed reduced dust due to rainfall and humidity.	control measures limits policy applicability.
S. Kameswaran et al., 2019	Dust pollution adversely affected vegetation physiology, causing stomatal closure, reduced photosynthesis, chlorosis, and soil chemistry alterations. Long-term dust deposition impacted plant growth.	Mostly qualitative synthesis. Quantitative field-based studies linking dust load with specific vegetation damage thresholds are lacking.
Sumita Kedia et al., 2018	Dust storm significantly altered aerosol properties and atmospheric temperature profiles. Surface cooling and negative radiative forcing at TOA observed. Dust layers extended up to 3-4 km altitude.	Limited focus on ground-level air quality and health implications. Regional validation using observational data was minimal.
Gajanan Shelke et al., 2017	High particulate matter concentrations detected in Aurangabad, while SO ₂ and NO ₂ remained within permissible limits. PM identified as major pollutant.	Source identification and health impact analysis were not performed. Temporal variability was also not addressed.
Geetanjali Kaushik et al., 2016	PM ₁₀ concentrations were highest in congested, high-traffic areas of Aurangabad. Poor road conditions and vehicle idling were major contributors.	Lack of quantitative emission estimates and absence of mitigation strategy evaluation. No seasonal comparison conducted.

Research Gap

Research on dust pollution has traditionally concentrated on specific aspects, such as particulate matter levels, metal contamination, air quality, or dust storms, without considering them in tandem. In Aurangabad, there is a scarcity of studies examining dust levels, with even fewer investigations delving into the specifics of industrial areas. While the general impact of dust on plant life has been explored, in-depth field studies on plants affected by dust are rare. Metal content analysis in dust has been conducted in certain areas, but a thorough examination of dust-borne metals in Aurangabad remains to be done. The presence of microorganisms in dust, which could have significant health implications, has been largely overlooked in existing research. Health issues stemming from dust exposure are often evaluated indirectly, without being directly linked to actual health outcomes. Some studies propose measures to mitigate dust pollution, but the potential of using plants as a viable, eco-friendly solution to reduce dust pollution has not been fully investigated. Consequently, a comprehensive study that encompasses dust monitoring, the effects of dust on plants, metal and microbial dust analysis, human health consequences, and the potential of plants to alleviate dust pollution is necessary for Aurangabad.

4. Methodology

Research was undertaken in Aurangabad city to evaluate the impact of dust pollution on the environment and human well-being. The investigation focused on monitoring airborne dust levels in various parts of the city. To achieve this, sampling sites were chosen to represent areas with high vehicle traffic, residential zones, industrial areas, and suburban regions. Using standardized equipment, air and dust samples were gathered from residential, industrial, and high-traffic areas to measure particulate matter concentrations. Laboratory analysis of dust samples involved assessing heavy metal presence and microbial content using established chemical and microbiological techniques. The effects of dust accumulation on plant life were examined by inspecting leaves from roadside and industrial areas. A health questionnaire was administered to residents in proximity to the sampling sites to identify dust-related health concerns. The compiled data underwent statistical analysis and geographic mapping to investigate spatial patterns and assess the mitigating role of vegetation in reducing dust pollution.

A study involving 72 Aurangabad residents from various neighborhoods aimed to gauge the impact of dust pollution on health and assess public knowledge. Participants were asked about the frequency of respiratory issues, including coughing, wheezing, and asthma, as well as their perceptions of dust pollution causes, awareness of associated health risks, and self-protective measures like wearing face masks and utilizing air purifiers.

Dust samples underwent laboratory analysis utilizing suitable chemical and microbiological tools to estimate heavy metal levels and identify microorganisms. Spatial mapping and analysis were conducted using Q-GIS Geographic Information System software to visualize dust pollution and associated factors in Aurangabad city.

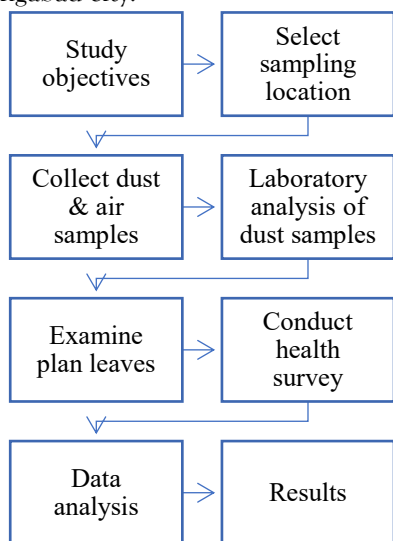


Fig. 5 Methodology Flowchart

5. Analysis and Results

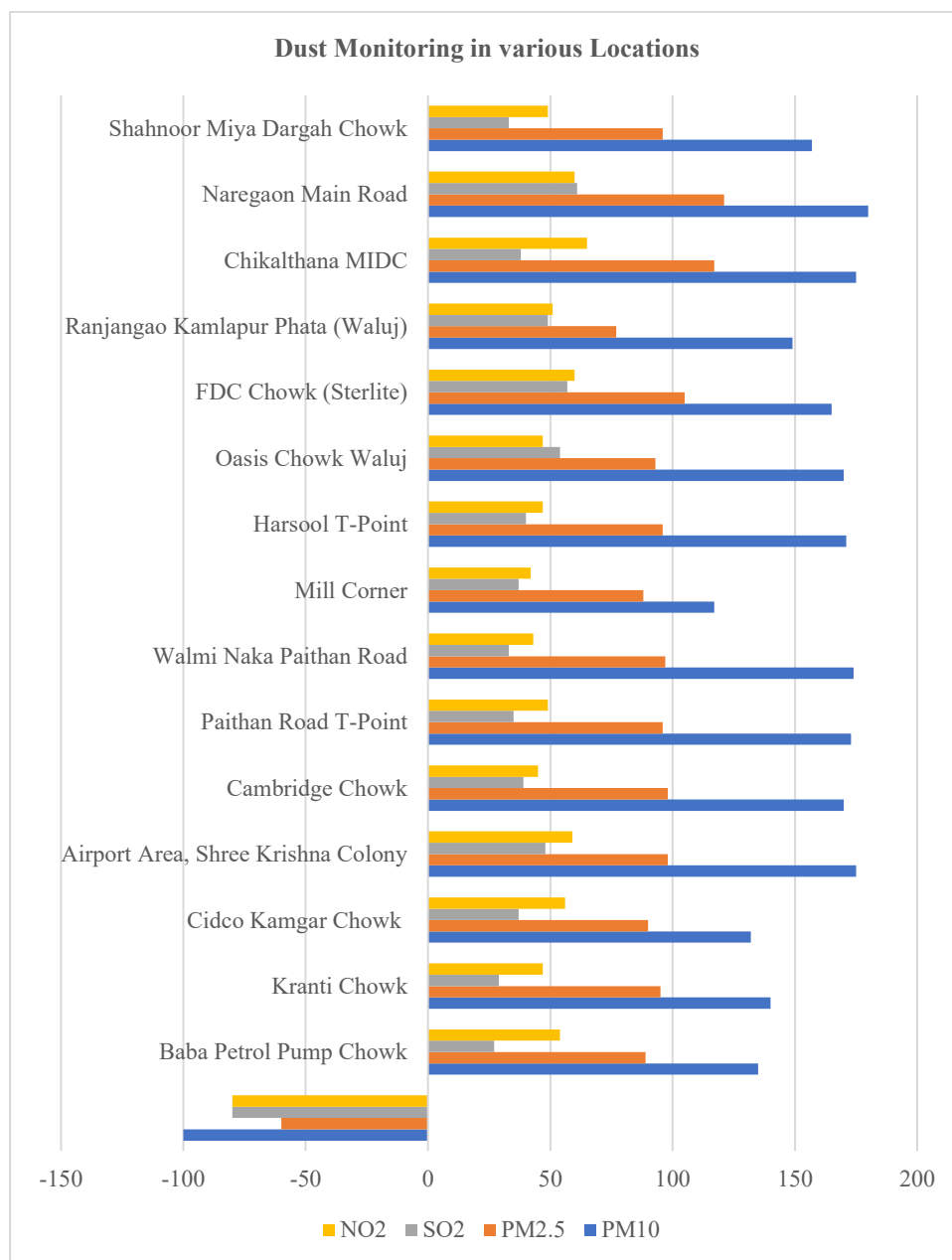
Air quality assessments were conducted at various sites throughout Aurangabad to evaluate the distribution of particulate and gaseous pollutants. Monitoring locations were chosen to represent a range of environments, including residential neighborhoods, commercial districts, industrial areas, and busy intersections. Levels of PM₁₀, PM_{2.5}, SO₂, and NO₂ were recorded from December 2023 to January 2024 and benchmarked against the National Ambient Air Quality Standards. The findings offer insights into the city's air pollution levels, highlighting areas most affected by traffic, industry, and road dust.

Ambient air sampling was performed utilizing an Envirotech APM 460 Respirable Dust Sampler, adhering to the Cyclonic Flow Technique as outlined in IS 5182 (Part 23) guidelines. Prior to use, glass microfiber and PTFE filter papers were stabilized in a desiccator for 24 hours and weighed using a precision analytical balance. The sampler was positioned at a suitable height above ground level, with air drawn through the cyclonic inlet at a controlled rate for a continuous 24-hour period. Following sampling, the filters were carefully extracted, re-stabilized, and re-weighed to determine the mass of collected particulate matter. The concentration of particulate matter was then calculated using established gravimetric formulas, based on the increase in filter weight and total sampled air volume.

Table 2 Dust Monitoring in various Locations

Sr. No	Location	PM10 (100)	PM2.5 (60)	SO2 (80)	NO2 (80)
1	Baba Petrol Pump Chowk	135	89	27	54
2	Kranti Chowk	140	95	29	47

3	Cidco Kamgar Chowk	132	90	37	56
4	Airport Area, Shree Krishna Colony	175	98	48	59
5	Cambridge Chowk	170	98	39	45
6	Paithan Road T-Point	173	96	35	49
7	Walmi Naka Paithan Road	174	97	33	43
8	Mill Corner	117	88	37	42
9	Harsool T-Point	171	96	40	47
10	Oasis Chowk Waluj	170	93	54	47
11	FDC Chowk (Sterlite)	165	105	57	60
12	Ranjangao Kamlapur Phata (Waluj)	149	77	49	51
13	Chikalthana MIDC	175	117	38	65
14	Naregaon Main Road	180	121	61	60
15	Shahnoor Miya Dargah Chowk	157	96	33	49



Graph 1 Dust Monitoring in various Locations

The dust monitoring data from 15 locations suggest that particle matter is the most serious air quality problem, while gaseous pollutants are below allowed levels. Prescribed standards include PM₁₀ (100 µg/m³), PM_{2.5} (60 µg/m³), SO₂ (80 µg/m³), and NO₂ (80 µg/m³). PM₁₀ values at all monitoring locations exceed the permitted limit, ranging from 117 µg/m³ at Mill Corner to the maximum value of 180 µg/m³ at Naregaon Main Road, showing extensive dust pollution caused by heavy traffic, construction activities, industrial operations, and road dust. PM_{2.5} levels are above the standard at all locations, with values ranging from 77 µg/m³ at Ranjangaon Kamlapur Phata (Waluj) to 121 µg/m³ at Naregaon Main Road, followed by 117 µg/m³ at Chikalhana MIDC and 105 µg/m³ at FDC Chowk, indicating serious health risks due to fine particulate exposure. Sulphur dioxide (SO₂) levels are within permissible limits at all sites, ranging from 27 µg/m³ to 61 µg/m³. Nitrogen dioxide (NO₂) concentrations are also acceptable, ranging from 42 µg/m³ to 65 µg/m³, with higher values observed in traffic-heavy and industrial areas. Overall, the data show that, while gaseous pollutants are under control, excessive particulate matter pollution is a major environmental and public health concern in all

monitored areas, necessitating immediate control measures such as dust suppression, better traffic management, industrial emission regulation, and increased green cover.

In contrast to other pollutants, the levels of SO₂ and NO₂ were largely within acceptable limits across most areas. The concentrations of SO₂ fell between 27 µg/m³ and 61 µg/m³, and NO₂ levels ranged from 42 µg/m³ to 65 µg/m³. Industrial zones, such as Waluj and Chikalthana MIDC, experienced slightly elevated levels of gaseous pollutants, although these remained below national thresholds. The data indicates that particulate matter, particularly PM₁₀ and PM_{2.5}, is the primary air pollutant in Aurangabad, whereas gaseous pollutants are relatively contained. The high dust levels are primarily due to traffic, industrial discharge, construction, and the resuspension of road dust.



Fig. 6 Aurangabad City selected various Zones

The results of air quality monitoring in Aurangabad revealed elevated levels of particulate matter across all examined areas. The high-traffic area had average concentrations of 180 µg/m³ for PM₁₀ and 110 µg/m³ for PM_{2.5}. A residential area undergoing construction exhibited average concentrations of 160 µg/m³ for PM₁₀ and 95 µg/m³ for PM_{2.5}. The most polluted area was the industrial zone, with average concentrations of 200 µg/m³ for PM₁₀ and 130 µg/m³ for PM_{2.5}. In a suburban area with unpaved roads, the average concentrations were 150 µg/m³ for PM₁₀ and 85 µg/m³ for PM_{2.5}. Compared to the National Ambient Air Quality Standards, which set limits at 100 µg/m³ for PM₁₀ and 60 µg/m³ for PM_{2.5}, all areas surpassed the allowed thresholds, signifying severe dust pollution, particularly during periods of high activity.

An analysis of field observations and air quality data revealed the primary sources of dust pollution in Aurangabad. Construction activities accounted for approximately 40% of the total, followed by vehicle emissions at around 30%, unpaved roads at 20%, and industrial emissions making up the remaining 10%.

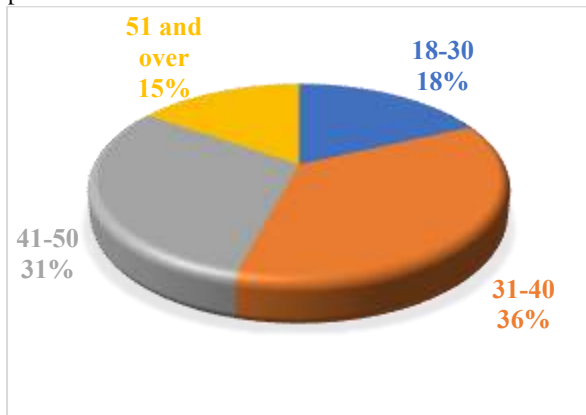
Health survey

This section analyzes the results of a health survey assessing the effects of dust pollution on human health in Aurangabad. Rapid urban growth, construction, vehicle emissions, and industrial activities have made dust pollution a major environmental issue in the city. Long-term inhalation of airborne dust poses substantial risks to the environment, biology, and public health, with a notable impact on respiratory health.

A health survey of 72 Aurangabad residents from various zones evaluated the effects of dust pollution on health and public awareness. The survey questioned participants about respiratory issues like coughing, wheezing, and asthma, as well as their perceptions of dust pollution sources, awareness of related health dangers, and the use of protective measures, including face masks and air purifiers.

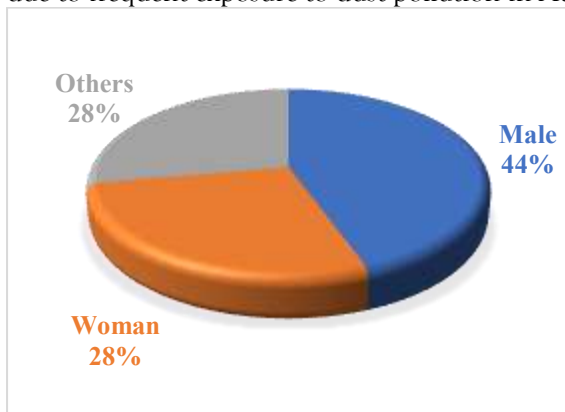
The analysis and results seek to pinpoint trends in health symptoms, assess public knowledge, and examine how people react to dust exposure. This section offers a deeper understanding of dust pollution's effects on human health in Aurangabad by comparing residents' views with documented health issues. The discoveries add to the overall comprehension of dust pollution's environmental and

biological consequences, emphasizing the importance of implementing targeted mitigation measures and public health initiatives.



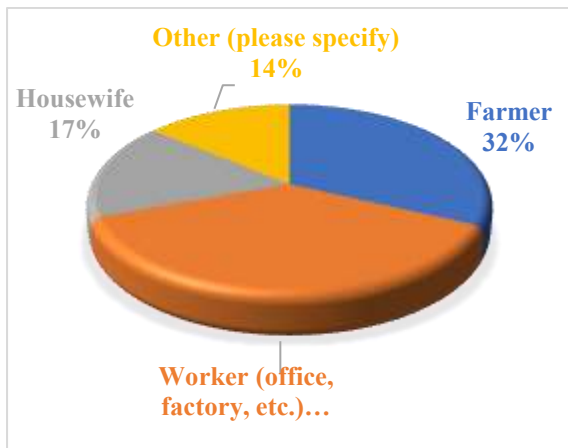
Graph 2 Age

The age distribution of respondents revealed that 36% fell within the 31-40 year range, while 31% were between 41-50 years old. The 18-30 year age group comprised 18% of the sample, and those 51 years and older made up 15%. The majority of responses, 67%, came from individuals between 31-50 years, likely due to frequent exposure to dust pollution in Aurangabad.



Graph 3 Gender

The collected gender data reveals that males accounted for 44% (32) of the responses, females comprised 28% (20), and the remaining 28% (20) identified with other gender categories, indicating a relatively balanced representation and diverse viewpoints on dust pollution's effects in Aurangabad.



Graph 4 Business

The survey of business respondents revealed that 37% (27) were employed in offices or factories, constituting the largest segment, while 32% (23) were farmers. Housewives made up 17% (12) of the sample, and 14% (10) had other occupations. The majority of participants worked in settings vulnerable to dust pollution in Aurangabad.

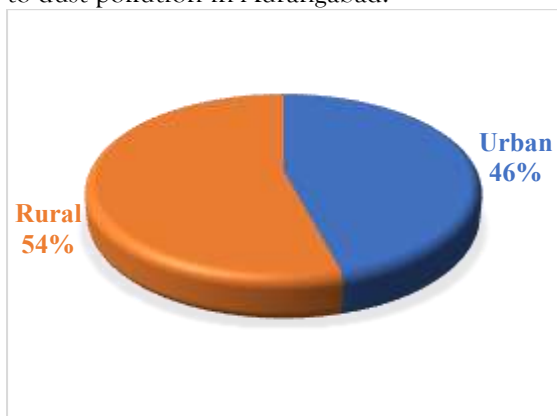


Figure 6 Location of residence

As per the responses collected towards place of residence, 54% (39) were from rural areas, while 46% (33) resided in urban areas. This indicates that the study captured perspectives from both rural and urban

populations, with slightly higher participation from rural residents affected by dust pollution in and around Aurangabad.



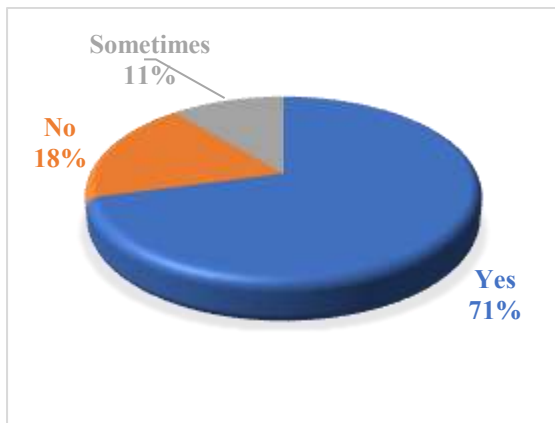
Graph 5 There is dust pollution in the area

Residents of Aurangabad largely consider dust pollution a concern, with 77% (55) of respondents reporting its presence in their area. Conversely, 15% (11) claimed there was no issue, and 8% (6) were uncertain, highlighting the widespread perception of dust pollution in the area.



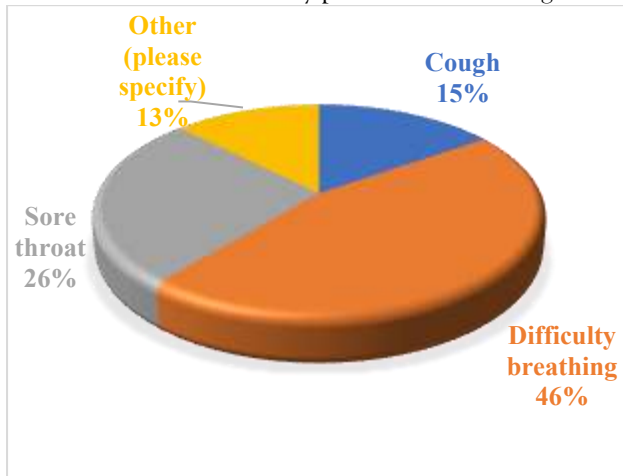
Graph 6 Time to stay outside from pollution

The survey on outdoor time amidst pollution revealed that 81% of respondents, or 58 individuals, spend 1-2 hours outside daily. Meanwhile, 14% (10 people) are outdoors for 2-4 hours, and just 5% (4 individuals) stay outside for four hours or more, indicating limited outdoor exposure among most, despite potential dust pollution impact in Aurangabad.



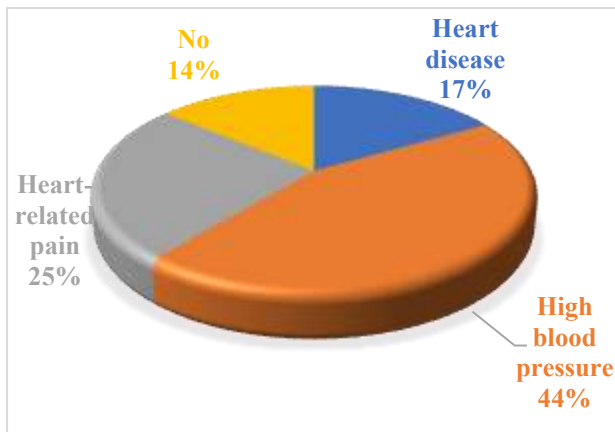
Graph 7 Regularly suffer from pollution

As per the responses collected towards regularly suffer from pollution, 71% (51) reported that they regularly suffer from pollution. Meanwhile, 18% (13) stated they do not suffer from pollution, and 11% (8) reported experiencing pollution-related problems sometimes. This indicates that a large proportion of residents are affected by pollution in Aurangabad.



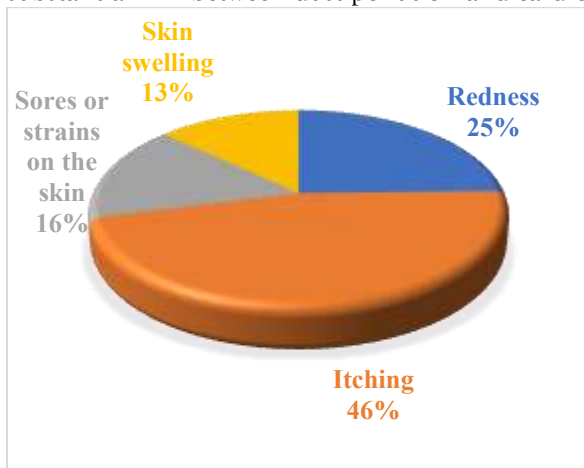
Graph 8 Breathing problems due to dust pollution

Responses regarding breathing difficulties caused by dust pollution revealed that 46% (33) of individuals experienced breathing troubles, 26% (19) had throat irritation, 15% (11) suffered from coughing, and 13% (9) reported other respiratory issues, indicating that respiratory problems are prevalent among Aurangabad residents exposed to dust pollution.



Graph 9 Heart-related problems due to dust pollution

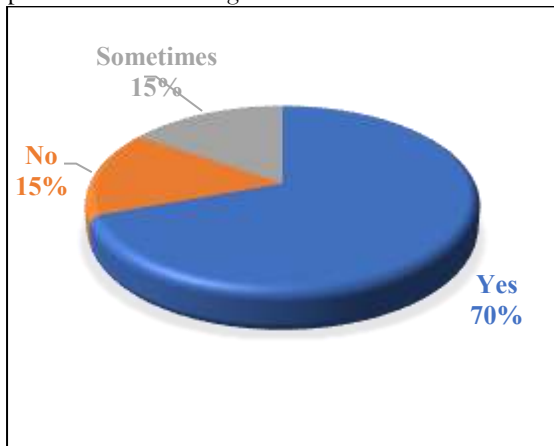
Responses regarding heart problems caused by dust pollution revealed that 44% of respondents (32 individuals) suffered from high blood pressure, 25% (18 individuals) experienced cardiac pain, and 17% (12 individuals) had heart disease, whereas 14% (10 individuals) reported no heart issues, suggesting a substantial link between dust pollution and cardiovascular problems in Aurangabad.



Graph 10 Skin-related problems due to dust pollution

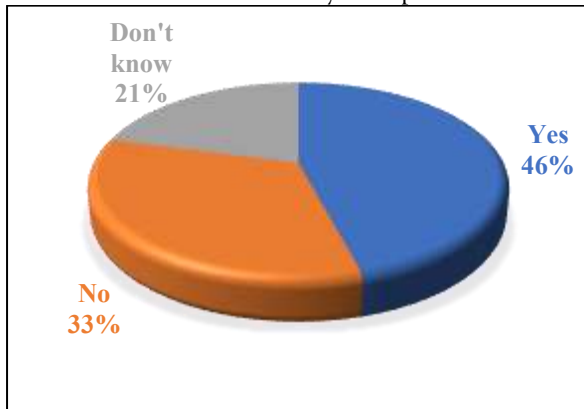
As per the responses collected towards skin-related problems due to dust pollution, 46% (32) reported experiencing itching, 25% (17) had skin redness, 16% (11) suffered from sores or strains, and 13% (9)

experienced skin swelling. This shows that skin issues are common among residents exposed to dust pollution in Aurangabad.



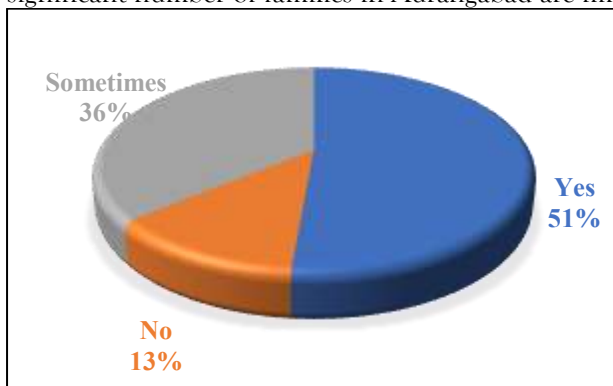
Graph 11 Physically or mentally tired due to dust pollution

As per the responses collected towards physically or mentally tired due to dust pollution, 69% (50) reported feeling physically or mentally tired, 15% (11) said they do not feel tired, and 15% (11) sometimes feel tired. This indicates that fatigue, both physical and mental, is a common issue among residents in areas affected by dust pollution in Aurangabad.



Graph 12 Family members suffered from any serious physical problems due to dust pollution

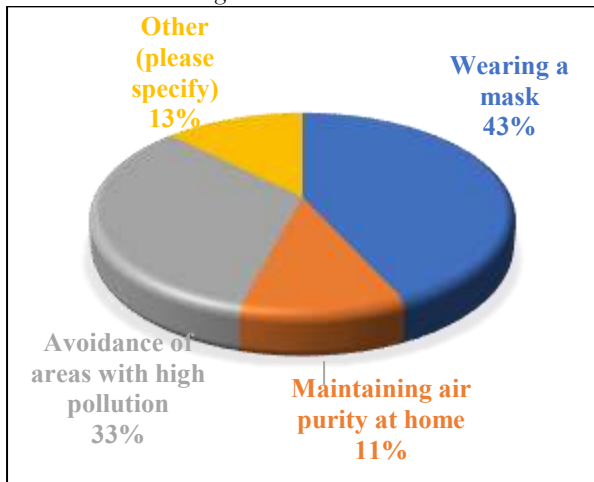
Responses from families about serious physical issues caused by dust pollution revealed that 46% experienced such problems, while 33% reported none and 21% were uncertain. The data indicates a significant number of families in Aurangabad are impacted by dust pollution-related health concerns.



Graph 13 Changes done in your lifestyle due to dust pollution

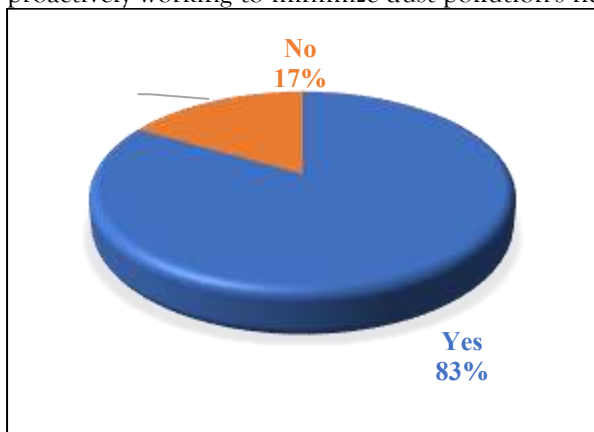
Responses regarding lifestyle adjustments due to dust pollution revealed that 51% of participants, or 37 individuals, made changes, while 36%, or 26 people, modified their habits occasionally, and 13%, or 9

individuals, made no alterations, demonstrating a significant impact of dust pollution on the daily routines of Aurangabad's residents.



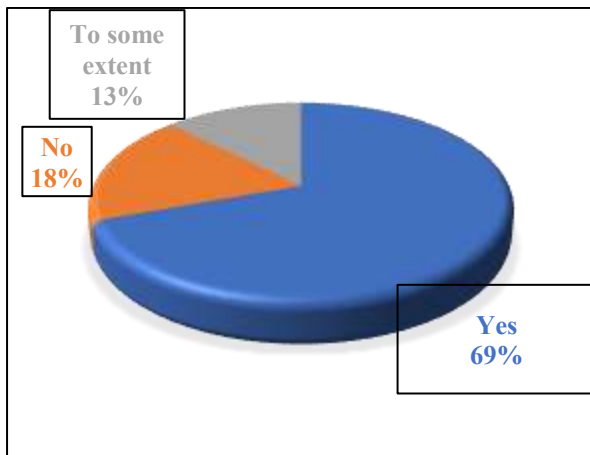
Graph 14 Measures taken to protect yourself from the effects of pollution

In response to measures for mitigating pollution's effects, 43% (31) of respondents used masks for protection, while 33% (24) avoided highly polluted areas. Additionally, 11% (8) prioritized indoor air quality and 13% (9) employed other strategies. These findings indicate that Aurangabad residents are proactively working to minimize dust pollution's health impact.



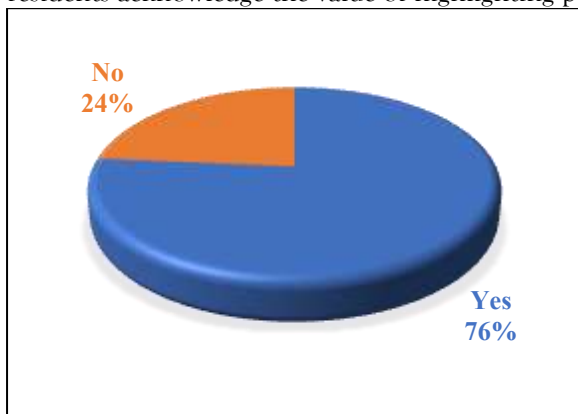
Graph 15 Take care of your health due to pollution

In response to concerns about health and pollution, 83% of respondents (60 individuals) take measures to protect their health, whereas 17% (12 individuals) do not. This suggests that the majority of Aurangabad residents are aware of the need to safeguard their health against dust pollution's impact.



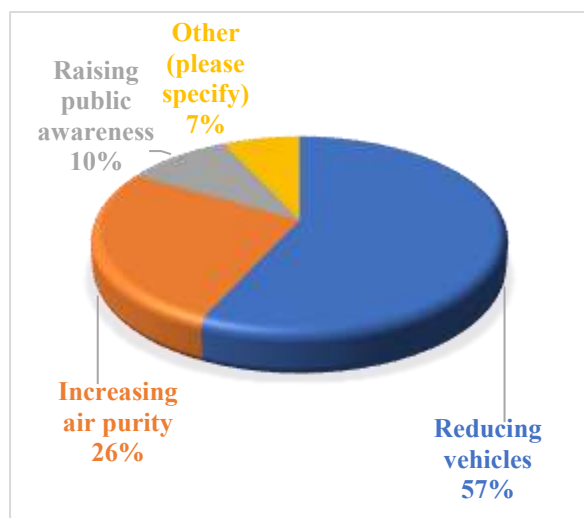
Graph 16 There should be public awareness about pollution and its effects

Responses gathered on public awareness about pollution revealed that 69% of participants, or 50 individuals, supported increasing awareness, while 18%, or 13 people, opposed it, and 13%, or 9 individuals, believed it was necessary to a certain extent, indicating that a majority of Aurangabad's residents acknowledge the value of highlighting pollution's effects on health.



Graph 17 Respiratory problems due to dust pollution

Responses regarding respiratory issues caused by dust pollution revealed that 76% of participants, or 55 individuals, felt compelled to seek medical attention, whereas 24%, or 17 people, did not. This suggests that respiratory problems are a prevalent concern for Aurangabad residents impacted by dust pollution.



Graph 18 Measures to control pollution

Pollution control measures were assessed through collected responses, revealing 57% (41) favored decreasing vehicle numbers, 26% (19) proposed enhancing air quality, 10% (7) advocated for increased public awareness, and 7% (5) cited alternative solutions. The majority of residents believe reducing vehicles is crucial to addressing Aurangabad's dust pollution.

Aurangabad city's health survey reveals that dust pollution substantially impacts respiratory, cardiovascular, and skin health, affecting daily life, and underscores the necessity for public awareness and effective measures to mitigate its effects.

6. CONCLUSION

The results of this research underscore the significance of dust pollution as a pressing environmental and public health issue in Aurangabad. Levels of particulate matter, specifically PM_{10} and $PM_{2.5}$, surpassed acceptable thresholds in all areas under observation, with the most severe contamination found near industrial areas, busy intersections, and construction sites. Although gaseous pollutants like SO_2 and NO_2 generally remained within safe limits, the elevated levels of particulate matter pose substantial health risks, including respiratory and cardiovascular issues. The study found that concentrations of PM_{10} ranged from $117 \mu\text{g}/\text{m}^3$ to $180 \mu\text{g}/\text{m}^3$, while $PM_{2.5}$ levels spanned from $77 \mu\text{g}/\text{m}^3$ to $121 \mu\text{g}/\text{m}^3$, exceeding national air quality standards at all monitoring locations, with the highest concentrations observed in industrial and high-traffic areas. A survey of 72 Aurangabad residents shed light on the severe health consequences of dust pollution. The majority of respondents (67%) fell within the 31–50 age bracket, representing a balanced mix of genders and occupations. Approximately 77% of participants reported experiencing dust pollution in their vicinity, with 71% frequently suffering from its effects. Common health complaints included respiratory issues (46%), hypertension (44%), skin irritation (46%), and exhaustion (69%). In response, many residents (51%) modified their daily habits, adopting preventive measures such as mask-wearing (43%) and avoiding polluted zones (33%). A significant proportion (69%) stressed the importance of public awareness, while 57% suggested reducing vehicle numbers as a means to curb pollution, highlighting the need for immediate mitigation strategies. In Aurangabad, SO_2 and NO_2 levels were generally within acceptable limits, suggesting that particulate matter is the main air pollutant. The main sources of dust pollution were construction (40%), vehicle emissions (30%), unpaved roads (20%), and industrial emissions (10%). To decrease pollution and safeguard human health and the urban environment, measures such as better traffic management, construction site regulations, paving roads, and increasing urban green spaces are essential.

7. Future Scope

The results of this research lay the groundwork for additional investigations and strategies to minimize dust pollution in Aurangabad city. Potential future studies could involve monitoring air quality over extended periods and across various seasons to document fluctuations in particulate matter and gaseous pollutants. Utilizing cutting-edge methods, such as real-time air monitoring systems, satellite imaging, and predictive models based on machine learning, could enhance the precision of dust pollution assessments and facilitate the identification of high-pollution areas. Investigations into the efficacy of urban green spaces, natural barriers, and road surface modifications in reducing dust buildup and enhancing air quality could also yield valuable insights. Furthermore, in-depth epidemiological research examining the correlation between prolonged exposure to particulate matter and specific health consequences would inform public health policy. Studies focused on practical solutions, including affordable dust reduction technologies, sustainable urban development, and stricter regulations on traffic and construction, would provide further support for implementable solutions. Ultimately, combining scientific inquiry with policy initiatives and community outreach programs can contribute to a reduction in dust pollution and its detrimental impacts on human health and the urban ecosystem.

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