



KeSEBAE NEWS



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Urban Air Quality Management

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Air quality is the measure of the purity and healthiness of the air we breathe, determined by the levels of substances present, which include particulates and gaseous pollutants. In urban centres, air quality is shaped by high population density, traffic congestion, industrial activity, energy use, waste burning, construction and limited air circulation. It is assessed through a combination of ground-based monitoring stations, satellite observations and atmospheric modelling, which together help determine whether pollutant levels comply with national or international air quality standards. The World Health Organisation, WHO, Air Quality Guidelines serve as a global reference, providing recommended limits for major pollutants such as particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide, NO₂, Sulphur dioxide, SO₂, ozone, O₃, and carbon monoxide, CO. These guidelines identify pollutant concentrations associated with the lowest possible health risks. For example, WHO recommends that the annual mean concentration of PM_{2.5} should not exceed 5 µg/m³, while the 24-hour mean should not exceed 15 µg/m³. Although WHO guidelines are not legally binding, they act as a gold standard that countries can adopt or adapt based on local feasibility, pollution levels and regulatory capacity. In Kenya, the National Environment Management Authority, NEMA, is the primary body responsible for regulating and enforcing air quality standards. While NEMA has established guidelines and policies to manage key pollutants such as particulate matter, nitrogen dioxide, sulphur dioxide and ozone, publicly accessible and up-to-date details of Kenya's specific pollutant limit values remain limited, particularly for fine particulates such as PM_{2.5}.

DEAR READER

Welcome to KeSEBAE Newsletter.

A monthly Newsletter touching on topical issues affecting our environment.

KeSEBAE NEWS is a Newsletter of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE)

Inside this Issue!

Pg. 1
Urban Air Quality Management

Pg. 11
KeSEBAE Conference 2026/ Call for Papers

Pg. 12
Call for Papers for The Next Editions of JEA and KeSEBAE NEWS

Pg. 13
Call for Membership

1.0 Air Pollutants in Urban Centres

Urban air quality is shaped by a complex mix of human and natural sources. In cities like Nairobi, transportation plays a major role, with emissions from cars, buses, trucks and motorcycles releasing carbon monoxide, nitrogen oxides and particulate matter, especially in traffic-congested areas. Industrial activities such as factories, power plants and manufacturing sites add smoke, dust and chemical pollutants to the air. Small-scale businesses and informal enterprises, including roadside workshops, salons and food stalls, contribute through diesel generators, charcoal or kerosene cooking and solvent use. Household activities, particularly cooking and heating with charcoal, firewood, or kerosene, produce fine particles and carbon monoxide.

Waste also affects air quality, not only through open burning of refuse but also from the decomposition of unmanaged waste at dumpsites like Dandora and Kawangware, which releases foul-smelling gases and methane. Construction activities and road dust from demolition, excavation and traffic on unpaved roads increase suspended particulates. Even peri-urban agriculture, including crop residue burning and fertilizer use, and natural sources like windblown dust and plant emissions, add to the mix. Together, these sources create a combination of particulate matter, carbon monoxide, nitrogen oxides, sulphur dioxide, volatile organic compounds and other pollutants that reduce air quality and affect public health in urban areas.

i. **Particulate Matter (PM_{2.5} and PM₁₀)**

Particulate matter comes from vehicle exhaust, road dust, construction sites, industrial emissions and cooking with charcoal or firewood.

ii. **Nitrogen Oxides (NO_x)**

Nitrogen oxides mainly come from vehicles, generators and industrial fuel burning. They contribute to smog and the formation of ground-level ozone.



Figure 1: Black exhaust fumes from lorry envelope a motorcyclist and his passenger on a busy road in the Kenyan capital, Nairobi.

Source: *The Conversation-*
<https://theconversation.com/nairobis-air-has-been-polluted-for-decades-new-review-suggests-a-path-forward-151077>

iii. **Sulphur Dioxide (SO₂)**

Sulphur dioxide is released by industries that burn sulphur-rich fuels.

iv. **Carbon Monoxide (CO)**

Carbon monoxide is an invisible gas emitted by vehicles and generators.

v. **Ground-Level Ozone (O₃)**

Ground-level ozone forms when nitrogen oxides react with volatile organic compounds in sunlight.

vi. **Volatile Organic Compounds (VOCs)**

VOCs come from fuels, solvents, paints and industrial processes. They contribute to smog formation.

vii. **Heavy Metals and Toxic Chemicals**

Heavy metals such as lead, cadmium and mercury come from industry, traffic and informal e-waste recycling.

viii. **Biological Pollutants**

Waste dumps, poorly managed sewage, mould spores, bacteria, pollen and other micro-organisms fill the air, triggering allergies, asthma and respiratory infections.

ix. **Black Carbon**

Black carbon is produced by incomplete combustion from diesel engines, biomass burning and kerosene lamps.

2.0 Impacts of Urban Air Pollution

Air quality is critical because it directly affects human health, environmental sustainability and socio-economic well-being. Poor air quality is linked to a range of health problems, including respiratory illnesses, cardiovascular disease, lung cancer and developmental impacts in children.

2.1 Health Impacts

i. **Chronic Respiratory and Cardiovascular Diseases**

Long-term exposure to fine particulate matter (PM_{2.5}) increases the risk of chronic respiratory illnesses such as chronic obstructive pulmonary disease and cardiovascular conditions like heart disease. It is also

strongly associated with premature mortality due to its ability to penetrate deep into the lungs and bloodstream.

ii. **Asthma and Reduced Lung Function**

Nitrogen dioxide (NO₂) makes asthma worse and other respiratory disorders. People exposed to higher NO₂ levels over time often show reduced lung function, especially in children and those with pre-existing conditions.

iii. **Airway Inflammation**

Sulphur dioxide (SO₂) causes airway inflammation, which can lead to breathing difficulties and worsen symptoms in asthma patients and those with chronic lung disease.

iv. **Oxygen Deprivation**

Carbon monoxide (CO) lowers the amount of oxygen the blood can carry. This can cause tiredness, dizziness and stress on the heart, especially for people with heart conditions.

v. **Oxidative Lung Damage**

Ground-level ozone (O₃) harms lung tissues. It can cause coughing, wheezing and reduced lung capacity, especially during hot sunny days when ozone levels are high.

vi. **Neurotoxicity and Organ Damage**

Breathing in harmful chemicals such as volatile organic compounds (VOCs) and heavy metals like lead and mercury for long periods can damage the brain, kidneys and liver.

vii. **Allergies, Infections and Asthma Attacks**

Biological pollutants such as pollen, mould and bacteria increase the risk of infections and allergic reactions. They can also trigger asthma attacks, especially in young children, the elderly and people with weak immune systems.

2.2 Environmental Impacts of Urban Air Pollution

i. **Ecosystem Acidification**

Sulphur dioxide (SO₂) and nitrogen oxides (NO_x) contribute to the formation of acid rain. When deposited on soil and water bodies, acid rain alters pH levels, leading to nutrient depletion in soils, reduced agricultural

productivity and the acidification of lakes and streams, which endangers aquatic life.

ii. **Vegetation Damage and Reduced Crop Yields**

Ground-level ozone damages plant leaves. Over time, it slows plant growth and reduces crop production. Crops like wheat, beans and soybeans are especially sensitive.

iii. **Climate Change Effects**

Particulate matter, black carbon and tropospheric ozone act as short-lived climate pollutants. They absorb and scatter solar radiation, contributing to atmospheric warming. Black carbon, in particular, accelerates glacier melt when deposited on ice surfaces by reducing reflectivity.

iv. **Water Contamination and Eutrophication¹**

Air pollutants such as ammonia (NH₃), nitrogen oxides (NO_x) and heavy metals settle on water bodies through atmospheric deposition. This contributes to nutrient loading, algal blooms, and eutrophication. Pollutant runoff from urban areas also contaminates drinking water sources with toxic substances such as lead and mercury.

v. **Soil Degradation and Toxic Accumulation**

Heavy metals and persistent chemicals build up in soil over time. This reduces soil fertility, affects soil organisms and can contaminate crops.

vi. **Biodiversity Loss**

Air pollution changes habitats and harms sensitive plants and animals. Acidification, toxic chemicals and ozone damage reduce the number of species and weaken ecosystems.

vii. **Material and Infrastructure Damage**

Pollutants such as ozone, SO₂ and acidic particles corrode building materials, including metals, limestone and concrete. This accelerates the deterioration of infrastructure, historical monuments and public utilities, leading to increased maintenance costs for cities.

2.3 Economic Impacts of Urban Air Pollution

algae die, bacteria decompose them, using up oxygen in the water, which can lead to low-oxygen conditions that harm or kill fish and other aquatic life.

¹ Eutrophication is the process where a body of water becomes enriched with too many nutrients, such as nitrogen and phosphorus. These nutrients cause excessive growth of algae and aquatic plants, known as an algal bloom. When the

- i. **Higher Healthcare Costs**
The rise in pollution related illnesses such as asthma, heart disease and respiratory infections places a heavy financial burden on national and local health systems. Governments, insurers and households spend significantly more on medical treatment, hospital admissions and long term disease management.
- ii. **Reduced Workforce Productivity**
Poor air quality leads to more sick days, reduced physical performance and lower cognitive function among workers. Productivity losses arise from absenteeism when workers miss work due to illness and from presenteeism when they perform below capacity because of pollution related symptoms.
- iii. **Economic Losses from Premature Mortality**
High levels of fine particulate matter and other pollutants contribute to premature deaths, especially from cardiovascular and respiratory diseases. This results in long term economic losses as societies lose skilled labour, human capital and years of potential economic contribution.
- iv. **Damage to Infrastructure and Increased Maintenance Costs**
Corrosive pollutants such as sulphur dioxide, nitrogen oxides and acidic particles accelerate the deterioration of buildings, bridges, vehicles and public utilities. This forces governments and businesses to allocate more resources to repairs, cleaning, repainting and replacement of damaged infrastructure.
- v. **Higher Energy Demand and Costs**
Air pollution reduces atmospheric visibility and the amount of solar radiation reaching the ground, lowering the efficiency of solar energy systems. Smog and heat buildup also increase the demand for air conditioning, raising electricity consumption and operational costs for households and businesses.
- vi. **Reduced Tourism and Property Values**
Cities with persistent smog, poor visibility and degraded urban environments become less attractive to tourists and investors. Pollution lowers real estate values, especially in areas near industrial zones or major highways, leading to reduced municipal revenue from property taxes.

vii. **Lower Agricultural and Livestock Production**

Air pollutants reduce crop quality and yield. Livestock exposed to polluted air grow more slowly and get sick more easily, reducing food production.



Figure 2: Statue Eroded by Acid Rain

Source: <https://www.britannica.com/science/air-pollution/Ozone>

Poor air quality impacts highlight the urgent need for proactive urban air quality management. Effective management helps identify and control pollution sources, monitor air quality trends and implement policies that reduce emissions from transportation, industry, domestic activities and waste. By prioritizing air quality, cities can protect public health, enhance the environment and improve overall quality of life for residents.

3.0 Air Quality Management

Urban air quality management requires a holistic approach that brings together regulatory, technological, social and planning interventions. Rapid urbanisation, industrial expansion and increased motorisation have intensified pollution pressures in cities globally, including those in Kenya. Addressing these challenges effectively demands coordinated action across institutions, communities and sectors. This chapter presents a comprehensive framework for urban air quality management, encompassing regulatory measures, technological interventions, public awareness and participation, and policy integration and planning.

3.1 Air Quality Monitoring and Data

Air quality monitoring refers to the systematic measurement of pollutants in the atmosphere, tracking concentrations of substances. The primary purpose of monitoring is to generate reliable data that informs public health assessments, environmental policy, regulatory enforcement and urban planning. Such data enables understanding of where, when and to what extent air pollution occurs. A comprehensive monitoring system also facilitates dissemination of information to the public through Air Quality Indices (AQI), alerts and visual maps, allowing residents, policymakers and urban planners to make informed decisions.

Methods of Air Quality Monitoring and Data Collection

Urban air quality is measured using a combination of methods depending on resources, city size and local needs. The standard approaches include:

1. Fixed (reference-grade) monitoring stations

Permanent stations equipped with high-quality, scientifically validated instruments provide continuous sampling and analysis. These stations yield regulatory-grade data suitable for long-term trend analysis, compliance verification and health risk assessments.

These stations measure multiple pollutants including PM_{2.5}, PM₁₀, NO₂, SO₂, O₃, CO, VOCs using standard techniques such as beta attenuation monitors, BAM, or tapered element oscillating microbalance, TEOMs, for particulate matter and gas analysers, chemiluminescence for NO_x, UV absorption for ozone, for gaseous pollutants.

2. Low-cost sensor networks

To expand spatial coverage, many cities deploy networks of affordable sensors. While slightly less precise, these devices are valuable for detecting local variations and identifying pollution hotspots across neighbourhoods, roads, industrial areas and residential zones.

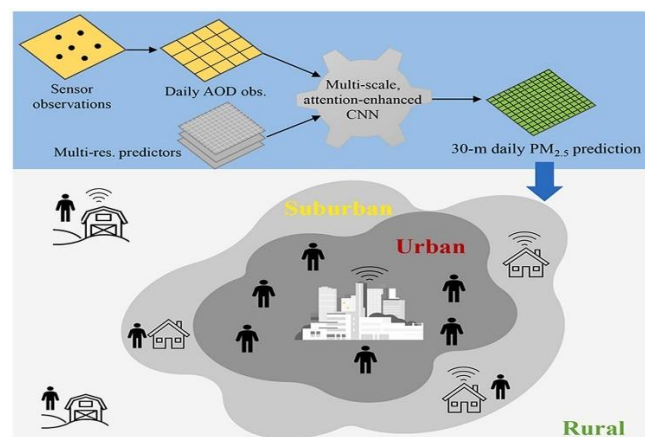


Figure 3: The location of mobile deployed sensors to cover areas not easily reachable by ground sensors or to complement ground measurements.

Source:

https://www.sciencedirect.com/science/article/pii/S0269749123008345?utm_source=chatgpt.com

3. Hybrid networks

Best practice combines reference stations for accuracy with numerous low-cost sensors for coverage, occasionally supplemented by mobile monitoring e.g., sensors mounted on vehicles or bicycles or satellite data to capture broader or inaccessible areas.

4. Data collection, processing and public access

Information from all sensors and stations is collected, quality-checked and processed to generate meaningful metrics such as hourly and daily averages, long-term trends, spatial maps and public-facing AQIs.

Given that air pollution can vary significantly over short distances and periods, affected by traffic, waste burning, or weather conditions, a dense and well-distributed network of sensors is crucial to capture the full picture.

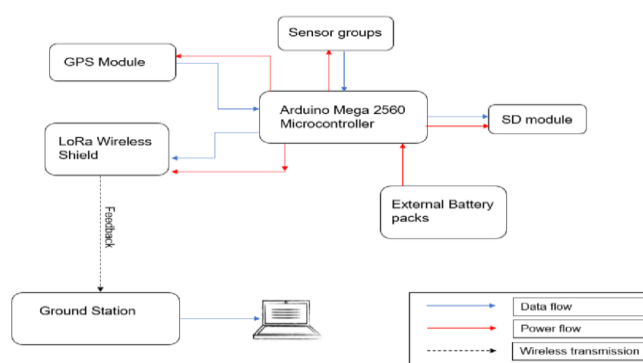


Figure 4: Schematic diagram of the air monitoring system

Source: https://www.researchgate.net/figure/Schematic-diagram-of-the-air-monitoring-system_fig1_329800765

In 2024, Nairobi County established two reference-grade air quality monitoring stations, located at Mama Lucy Kibaki Hospital and a central Fire Station along Tom Mboya Street. These stations provide continuous, high-precision measurements of key pollutants originating from traffic, waste emissions and ambient urban air.

Building on this foundation, in June 2025 the county launched its first city-owned air quality monitoring network under the Breathe Cities Nairobi programme, deploying 50 low-cost sensors across the city. Combined with existing monitoring equipment, Nairobi now operates a total of 87 sensors.

The sensors are strategically positioned across all 17 constituencies, covering major roads, residential areas, industrial zones and waste disposal sites. This spatial distribution ensures comprehensive monitoring of air quality variations across the city. To enhance data accessibility, Nairobi is developing a city-owned Air Quality Information Management System and public data portal. These platforms will provide real-time and historical air quality data to residents, researchers, and decision-makers, facilitating evidence-based analysis and decision-making.

In 2024, county environment officers underwent specialised training in air quality monitoring, data analysis and interpretation, strengthening local technical capacity for managing the monitoring network. The overarching goal of these initiatives is to generate robust, actionable data that supports policymaking, identifies pollution hotspots, guides targeted interventions such as traffic regulation, waste management and industrial emissions control, and ultimately improves public health outcomes.

3.2 Regulation and Standards

Regulations are the backbone of urban air quality management. They define acceptable pollution levels, set enforcement responsibilities and provide the legal framework for action. Globally recognised standards provide benchmarks for protecting public health and the environment.

The World Health Organization (WHO) Air Quality Guidelines set recommended limits for key pollutants, providing evidence-based thresholds that governments often use as a reference. For example, the WHO recommends:

- PM_{2.5}: 5 µg/m³ annual mean
- PM₁₀: 15 µg/m³ annual mean
- Nitrogen dioxide (NO₂): 10 µg/m³ annual mean

- Sulphur dioxide (SO₂): 40 µg/m³ 24-hour mean
- Ozone (O₃): 100 µg/m³ 8-hour mean

In the European Union, the Ambient Air Quality Directive (2008/50/EC) enforces limits for PM_{2.5}, PM₁₀, NO₂, SO₂, O₃ and lead, requiring member states to monitor, report, and implement corrective actions where needed. The United States Clean Air Act sets National Ambient Air Quality Standards (NAAQS) for PM_{2.5}, PM₁₀, NO₂, SO₂, CO, and O₃, with strict mechanisms for compliance from industries, power plants and transport. At the city level, London's Ultra Low Emission Zone (ULEZ) restricts high-polluting vehicles from central areas, achieving measurable reductions in nitrogen dioxide and particulate matter.

Kenya has developed a regulatory framework that aligns closely with these international standards. The Air Quality Regulations, 2014 provide maximum permissible limits for PM_{2.5}, PM₁₀, NO₂, SO₂, CO and O₃, forming the legal basis for monitoring and enforcement.

- **Vehicle Emission Standards:** Restrictions on importing vehicles older than eight years aim to reduce transport-related pollution.
- **Industrial Emission Requirements:** NEMA enforces emission limits through licensing, while Environmental Impact Assessments ensure new developments incorporate pollution control measures.
- **Fuel Quality Regulations:** Kenya has phased out leaded petrol and improved diesel quality to reduce combustion emissions.
- **Waste Management Controls:** Open burning of waste is restricted, though enforcement remains inconsistent, especially in informal settlements.

3.3 Technological Interventions

Technological interventions provide the tools to monitor, reduce and manage urban air pollution. They enable evidence-based decisions, control emissions at the source, and support efficient urban systems.

- **Air Quality Monitoring** uses reference-grade stations, low-cost sensors, mobile devices and satellites to measure pollutant concentrations, detect hotspots and track spatial and temporal variations. AI and predictive modelling forecast pollution episodes and guide timely interventions.
- **Cleaner Transport Technologies** reduce emissions from vehicles and traffic systems. Electric and hybrid vehicles lower tailpipe

pollutants, bus rapid transit systems optimise passenger flow and smart traffic management improves traffic efficiency to minimise congestion-related emissions.

- **Industrial Pollution Control** removes pollutants at their source. Electrostatic precipitators capture particulate matter, scrubbers neutralise gaseous pollutants, catalytic converters reduce nitrogen oxides and dust management systems control particulate emissions in industrial processes.
- **Cleaner Energy and Household Solutions** minimise emissions from energy use. Renewable energy sources replace fossil fuels, while LPG, biogas and improved cookstoves reduce pollution from domestic combustion.
- **Smart City Data Tools** integrate remote sensing, mapping, and AI modelling to identify pollution patterns, assess intervention effectiveness and support evidence-based policy planning.
- **Urban Mobility Infrastructure Technologies** support low-emission movement. Cycling and pedestrian networks encourage non-motorised transport, electric vehicle charging infrastructure enables cleaner mobility and intelligent transport systems optimise vehicle flow to reduce emissions.

3.4 Community Engagement and Behaviour

Community engagement is essential for effective urban air quality management. Public awareness, participation and behavioural change directly influence the success of interventions.

- **Public Awareness Campaigns** educate residents about pollution sources, health impacts, and mitigation measures. Large-scale initiatives, such as the United Kingdom's Clean Air Day, demonstrate how targeted communication can encourage protective behaviours and support compliance with air quality regulations.
- **Citizen Science and Participatory Monitoring** empower communities to collect and report air quality data, complementing official monitoring systems and increasing accountability. In the United States, community-led sensor networks provide hyper-

local data that informs municipal planning and pollution control.

- **Advocacy and Civil Society Engagement** mobilise public support for policy implementation and enforcement. In South Africa, environmental organisations successfully campaign for stronger industrial emission controls, influencing both local policy and corporate behaviour.
- **Behavioural Interventions and Lifestyle Changes** encourage adoption of low-emission transport and cleaner domestic practices. Germany's promotion of cycling and walking as primary modes of urban mobility exemplifies how community behaviour can reduce transport-related emissions.
- **Participation in Planning and Policy Decisions** ensures that interventions reflect local needs and priorities. In Canada, mandatory public consultation in environmental assessments demonstrates how citizen input strengthens policy relevance and compliance.

3.5 Policy Integration and Governance

Effective air quality management requires coordination across sectors, long-term strategies, and adaptive governance. Integration ensures that policies, regulations, and interventions work together to achieve sustained improvements.

- **Cross-Sectoral Coordination** aligns policies across transport, industry and energy to maximise impact. The United Kingdom's Clean Air Strategy demonstrates that harmonised cross-sector approaches effectively reduce urban pollution.
- **Linking Air Quality with Climate and Energy Policies** leverages synergies between emissions reduction and sustainability goals. Sweden integrates air quality objectives with renewable energy targets, reducing both greenhouse gases and urban pollutants.
- **Long-Term Strategic Planning** establishes multi-year roadmaps for consistent air quality improvements. Seoul's multi-year air quality programme provides structured targets and benchmarks to guide interventions over time.

- **Strategic Environmental Assessment (SEA)** evaluates the environmental impacts of policies and projects at early planning stages. The European Union routinely applies SEAs to major infrastructure and land-use initiatives, ensuring air quality considerations are incorporated from the outset.
- **Monitoring, Evaluation, and Adaptive Management** enables continuous improvement through data-driven decisions. Canada updates national frameworks based on monitoring results, ensuring policies remain effective and responsive to changing conditions.

3.6 Urban Form and Infrastructure

The design and layout of cities directly influence air quality by shaping pollution exposure, transport patterns and the effectiveness of mitigation measures. Strategic urban form and infrastructure planning are essential for sustainable management.

- **Integrating Air Quality into Urban Design** improves natural ventilation and reduces pollutant accumulation. In Copenhagen, street orientation and building layouts are planned to enhance airflow and disperse pollutants effectively.
- **Green and Active Transport Infrastructure** reduces reliance on private vehicles and lowers emissions. Bogotá's bike lanes and pedestrian plazas demonstrate how reallocating street space can directly improve local air quality.
- **Land-Use Planning and Zoning** separates industrial, residential and sensitive areas to minimise population exposure to pollutants.

Singapore buffers housing developments from major roads and industrial zones to protect residents from emissions.

- **Urban Greening and Public Spaces** absorb pollutants, improve air circulation and create healthier microenvironments. Medellín's targeted tree planting and green corridors reduce street-level pollution in densely populated areas.
- **Infrastructure Resilience and Maintenance** prevents emissions from road dust and congestion. In Japan, regular road maintenance and efficient public transport systems reduce particulate matter and improve traffic flow.
- **Evidence-Based Urban Planning** uses monitoring data to locate interventions where they have the greatest impact. European cities employ sensor networks to guide green corridors, traffic management, and street redesigns to optimise air quality outcomes.

4.0 Kenya Regulation, Standards and Enforcement Challenges

Effective urban air quality management relies on robust regulations, legally binding standards and consistent enforcement. Globally, the World Health Organization (WHO) Air Quality Guidelines provide evidence-based thresholds for key pollutants. Countries adopt or adapt these to suit local conditions, balancing public health protection with technical and economic feasibility.

In Kenya, the Air Quality Regulations of 2014 set the legal framework, supplemented by vehicle emission standards, industrial licensing and fuel quality requirements. Table 1 compares WHO guidelines with Kenyan regulatory limits and measured levels in Nairobi.

Table 1: Comparison of WHO Air Quality Guidelines and Kenya's Regulatory Limits with Nairobi Ambient Levels

Pollutant	WHO Guideline	Kenya Limit	Measured Ambient Level (Nairobi) ¹
PM _{2.5} – annual mean	5 µg/m ³	25 µg/m ³	~18.4 µg/m ³
PM _{2.5} – 24-hour mean	15 µg/m ³	–	~19.2 µg/m ³
PM ₁₀ – annual mean	15 µg/m ³	50 µg/m ³	~26.8 µg/m ³
NO ₂ – annual mean	10 µg/m ³	40 µg/m ³	~6.8 µg/m ³
SO ₂ – 24-hour mean	40 µg/m ³	125 µg/m ³	~2.2 µg/m ³

¹Values from Nairobi monitoring networks, representing city averages.

The comparison shows that while Nairobi's pollutant levels generally fall within Kenya's regulatory limits, they often exceed WHO-recommended thresholds, particularly for fine particulate matter. This highlights a persistent public health risk and indicates that current national standards are less protective than international guidelines.

Several practical constraints undermine effective regulation:

- **Capacity Constraints:** NEMA has limited technical staff and monitoring equipment to oversee emissions from industry, transport, and waste activities citywide.
- **Real-Time Monitoring:** Enforcement is largely periodic; automated, citywide compliance systems are absent.
- **Informal Settlements:** Open waste burning, unpaved roads and small-scale unregulated enterprises are difficult to monitor or control.
- **Urban Expansion:** Rapid urbanisation outpaces regulation; zoning and planning often fail to protect sensitive populations from exposure.
- **Industrial Compliance:** Many factories lack functional emission-control equipment; audits are inconsistent.
- **Transport Sector:** Vehicle inspections are irregular and a high proportion of older imported vehicles contributes to elevated emissions.

5.0 Case Study: Air Quality Management in Bogotá, Colombia

Bogotá, the capital of Colombia, sits on a high Andean plateau at about 2,600 metres above sea level, its vast urban area framed by encircling mountains. This striking geography also creates a persistent environmental challenge, as the basin-like landscape limits atmospheric dispersion and traps pollutants, especially during thermal inversions. By the early 2000s, the effects of this were unmistakable. Rapid urbanisation, reliance on diesel-powered transport and the expansion of informal industry had pushed PM_{10} and $PM_{2.5}$ concentrations far beyond World Health Organization guidelines. In 2019, poor air quality was linked to an estimated 2,300 excess deaths and as late as 2023 the city's average $PM_{2.5}$ levels remained three to four times higher than recommended global limits. These conditions contributed to rising respiratory illnesses, school absenteeism and increased healthcare expenditure.



Figure 5: A view of Bogotá's urban area surrounded by mountains

Bogotá has responded with a multi-faceted clean-air strategy. Over the past two decades it has aggressively upgraded transit, enforced emissions standards, expanded monitoring and run public outreach. These actions are credited with significant health and environmental benefits.

5.1 Interventions Undertaken

1. Transport Reforms



Figure 6: The TransMilenio BRT system, one of the largest globally.

The city launched TransMilenio in 2000, a bus rapid transit (BRT) system with dedicated lanes that now carries millions of passengers daily.

Core features included:

- Dedicated bus lanes
- Phased replacement of traditional diesel buses with Euro IV, V, and later electric buses
- Strict fleet maintenance requirements
- Reduced vehicle kilometres travelled through efficient routing

In recent years the city has added nearly 1,500 electric buses, opened two urban cable-car lines and begun constructing a metro line. At the same time, policymakers promoted non-motorised transport: over

600 km of cycle lanes now crisscross Bogotá, one of the largest networks in Latin America. To curb private car use, Bogotá has maintained strict “pico y placa” license restrictions and vehicle inspection programmes. Together, these measures have reduced congestion and emissions from the transport sector, mirroring global best practices.

2. Emissions Controls and Regulations

The government enforces vehicle inspection and fuel standards e.g. ultra-low-sulphur diesel and Euro-equivalent limits and controls industrial and construction pollution. It has also adopted contingency plans on bad-air days: for example, authorities advise factories to cut operations, urge freight trucks to avoid rush hours and reroute heavy vehicles away from dense areas during high-pollution episodes. These actions reduce peak exposures and support long-term improvements. Notably, in 2024 Bogotá unveiled Plan Aire 2030, its first Clean Air Master Plan and Clean Air Zone, aiming to cut pollution by 30% by 2030. This target (projected to save 840 lives a year and US\$1.7 billion) provides political momentum for enforcement of emissions standards citywide.

3. Monitoring, Forecasting and Public Engagement

Bogotá has built an extensive air-quality monitoring network and modern alert systems. Automated stations track pollutants (PM₁₀, PM_{2.5}, ozone, etc.), feeding real-time data into forecasts and warnings. WRI and partners helped upgrade this system (using tools like CanAIRy) to predict high-pollution periods. When alerts are issued, the city uses public communication to protect vulnerable groups: residents are advised to limit outdoor activity, switch from private cars to cleaner transit and avoid schoolyards during smog peaks. Community programs have also raised awareness: for example, the “*Barrios Vitales*” pilot engaged neighbourhoods in redesigning streets, adding bike lanes, parks and pedestrian plazas, to cut local pollution. In San Felipe, a residential area retrofitted under this program, estimated PM_{2.5} fell by 13% in one year, road crashes dropped 44% and public transit use jumped 81%. These data-driven community projects not only improved air quality locally but also built public support for the broader plan.²

² World Resources Institute. (2025, October 20). Bogotá, Colombia, uses data and smart urban design to cut air pollution. WRI Insights. Retrieved from <https://www.wri.org/insights/bogota-colombia-uses-data-and-smart-urban-design-cut-air-pollution>.

5.2 Outcomes of Bogotá’s Actions

Collectively, Bogotá’s policies have delivered measurable improvements in both air quality and public health. Evidence from local studies and international assessments shows that the city’s multi-sector reforms have produced sustained declines in key pollutants. The main outcomes include:

- Significant reductions in PM_{2.5} and other pollutants, with street-level interventions and cleaner transport options contributing to steady improvements across multiple districts.
- A city-wide 24 per cent reduction in air pollution since 2018, attributed to expanded public transport, greater uptake of cycling and walking and the introduction of more green public spaces.
- Substantial health benefits, including an estimated hundreds of deaths avoided and billions of shillings in reduced healthcare costs over the past decade.
- Greater resilience during pollution episodes, as better monitoring, cleaner fleets and public alerts have helped protect vulnerable groups.
- International recognition, most notably Bogotá’s 2025 Earthshot Prize win in the Clean Our Air category, affirming its leadership in tackling urban pollution.

5.3 What Kenya Can Adopt from Bogotá’s Experience

Kenya can draw several practical lessons from Bogotá’s air-quality progress. An integrated transport approach is essential. Nairobi’s move toward an electrified BRT system aligns well with Bogotá’s reforms and speeding up this project while prioritising electric buses would help cut emissions and ease congestion. Stronger vehicle inspections and higher fuel standards would reinforce these gains.

Better use of monitoring data is also important. Nairobi’s new sensor network should be linked to forecasting tools and public alerts so that information guides daily decisions. Bogotá’s practice of issuing timely warnings shows how effective this can be.

World Resources Institute. (2025, October 21). Improving air quality in Bogotá, Colombia, from the ground up. WRI Deep Dive Cities project update. Retrieved from <https://www.wri.org/update/improving-air-quality-bogota-colombia>.

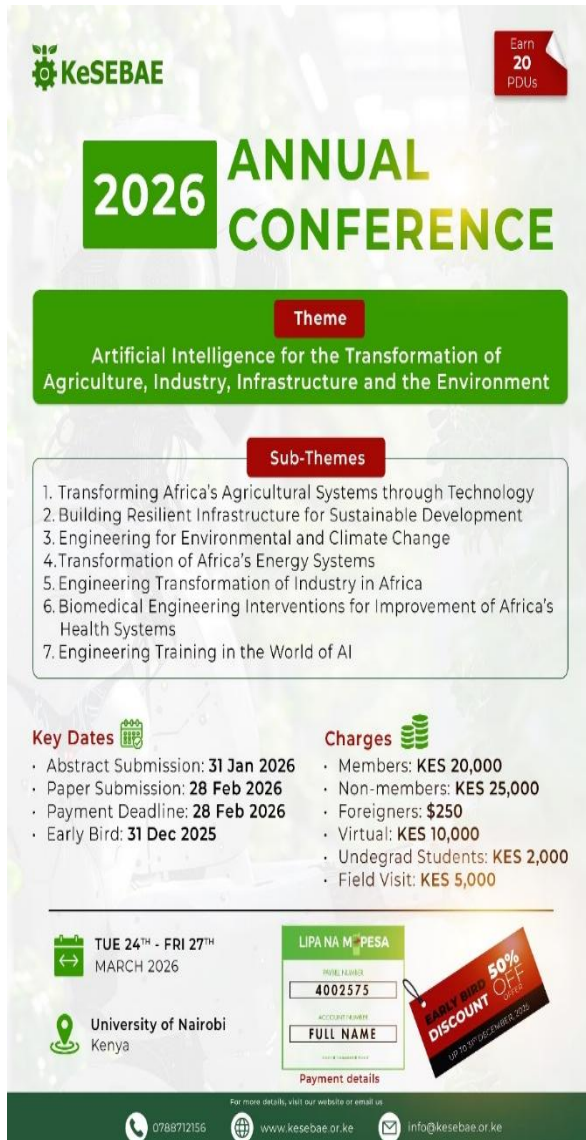
Neighbourhood design can play a major role as well. Bogotá's greening projects, safer walking routes and connected bike lanes have improved local air quality. Kenya could test similar street redesigns in busy urban areas to create green buffers, reduce exposure and encourage active travel.

Political commitment ties everything together. Nairobi has made progress by putting air quality into law and funding monitoring, but a clear air-quality master plan with targets and responsibilities would strengthen coordination across agencies.

Overall, Kenya can build on Bogotá's model by combining clean transport, firm emissions regulations, data-driven management and community-centred design to achieve lasting reductions in urban pollution.

6.0 Conclusion

In summary, urban air quality profoundly affects public health, the environment and economic productivity, with pollutants such as PM_{2.5}, NO₂, SO₂, O₃, VOCs and black carbon arising from transport, industry, domestic energy use, waste and construction. Kenya has established regulatory frameworks, emission standards, and a growing monitoring network, yet measured pollutant levels, particularly fine particulate matter, still exceed WHO guidelines. Enforcement challenges, limited technical capacity, informal settlement activities and rapid urbanisation further constrain effective management. Addressing urban air pollution, therefore, requires an integrated approach combining robust regulations, technological solutions, data-driven monitoring, community engagement and strategic urban planning to safeguard public health, protect ecosystems, and support sustainable city development.



KeSEBAE Earn 20 PDUs

2026 ANNUAL CONFERENCE

Theme
Artificial Intelligence for the Transformation of Agriculture, Industry, Infrastructure and the Environment

Sub-Themes

1. Transforming Africa's Agricultural Systems through Technology
2. Building Resilient Infrastructure for Sustainable Development
3. Engineering for Environmental and Climate Change
4. Transformation of Africa's Energy Systems
5. Engineering Transformation of Industry in Africa
6. Biomedical Engineering Interventions for Improvement of Africa's Health Systems
7. Engineering Training in the World of AI

Key Dates

- Abstract Submission: **31 Jan 2026**
- Paper Submission: **28 Feb 2026**
- Payment Deadline: **28 Feb 2026**
- Early Bird: **31 Dec 2025**

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5. Engineering Transformation of Industry in Africa
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