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Impact Of Types And Sources Of Waste On Air Quality In Nairobi City County, Kenya

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Abstract:
Background: *Rapid urbanization and population pressure in informal settlements have intensified solid waste generation and contributed to deteriorating air quality in many cities in the Global South. This study examined the types and sources of solid waste and their influence on air quality in Kibera Sub-County, Nairobi City County, Kenya. Anchored on Waste Management Theory and the Theory of Planned Behavior, the study adopted a cross-sectional research design integrating quantitative and qualitative approaches.*
Materials and Methods: *Data were collected from 384 households across the five wards of Kibera using structured questionnaires, key informant interviews, observation checklists, and secondary air-quality sensor data. Quantitative data were analyzed using descriptive statistics and inferential techniques, including correlation and multiple regression analysis.*
Results: *The findings revealed that domestic waste constituted the dominant waste stream, with 77.6% of respondents agreeing that most waste originated from households, mainly food remains, plastics, and paper (mean = 3.94, SD = 1.12). Commercial waste from markets and small businesses was also significant (mean = 3.82, SD = 0.97), while industrial waste from informal garages contributed hazardous residues such as used oil, scrap metal, and rubber materials (mean = 3.54, SD = 1.10). Waste dumping near homes and public pathways was widespread, recording the highest mean score (mean = 4.12, SD = 0.88). Air-quality measurements showed severe pollution episodes associated with waste accumulation and open burning. Particulate matter ($PM_{2.5}$) concentrations ranged from 10 µg/m³ to 150 µg/m³, exceeding the World Health Organization 24-hour guideline of 15 µg/m³, particularly at 10 m and 20 m from burning sites. Carbon monoxide concentrations ranged from 0 to 20 ppm, while sulphur dioxide ranged from 0 to 10 ppm during active burning events. Regression analysis indicated that types and sources of waste, waste management practices, and waste accumulation jointly explained 53.0% of the variation in air quality ($R^2 = 0.530$). Waste management practices had the strongest effect on air quality ($B = 0.407$, $p < 0.001$), followed by waste accumulation ($B = 0.321$, $p < 0.001$) and types and sources of waste ($B = 0.238$, $p < 0.001$). The study concludes that ineffective waste management characterized by unsegregated waste, accumulation, and open burning significantly degrades air quality in Kibera. Strengthening waste collection, enforcing anti-burning regulations, promoting household-level waste segregation, and supporting community-based waste management initiatives are critical for improving air quality and public health in informal settlements.*
Key Word: *Solid waste; Waste types and sources; Air quality; Informal settlements; Waste management practices*

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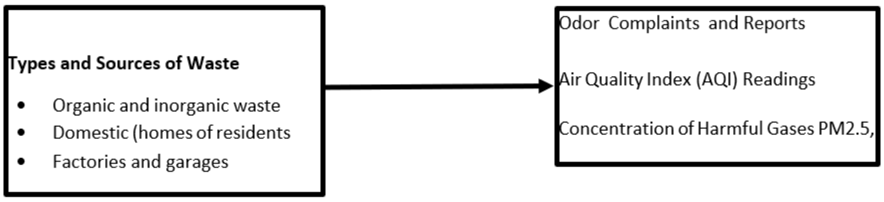
I. Introduction

Solid waste management has emerged as one of the most critical environmental and public health challenges confronting rapidly urbanizing cities worldwide, particularly in low- and middle-income countries where population growth, changing consumption patterns, and expansion of informal economic activities have intensified the volume and complexity of waste streams. In the absence of effective waste management systems, solid waste becomes a major source of environmental pollution, contributing to land degradation, water contamination, and deterioration of air quality. Informal settlements are disproportionately affected due to inadequate infrastructure, limited municipal service coverage, weak enforcement of environmental regulations, and low levels of waste segregation at source. In such settings, households and small-scale commercial operators frequently resort to open dumping and open burning of waste as coping mechanisms, practices that release harmful pollutants such as fine particulate matter ($PM_{2.5}$), carbon monoxide, sulphur dioxide, and other toxic gases that significantly degrade ambient air quality and pose serious risks to human health. In Kenya, rapid urbanization has intensified these challenges, particularly in Nairobi City County, where thousands of tonnes of solid waste are generated daily, yet collection services remain insufficient, especially within informal settlements. Consequently, uncollected waste accumulates near homes, markets, and public pathways, increasing the likelihood of open burning and prolonged exposure of residents to hazardous air pollutants associated with respiratory and cardiovascular diseases. Despite the existence of policy and legal frameworks aimed at improving waste management and air quality, implementation gaps persist due to limited financial resources, institutional capacity constraints, and low public awareness. Kibera Sub-County, one of the largest and most densely populated informal settlements in Nairobi City County, exemplifies these challenges, with high population density, mixed residential and commercial land use, and widespread informal economic activities generating diverse waste streams that overwhelm existing waste management systems. The close proximity of waste accumulation and disposal sites to residential areas further amplifies human exposure to pollutants released through waste decomposition and open burning. Understanding the types and sources of waste in such contexts is therefore fundamental to developing targeted and effective waste management interventions and improving air quality outcomes. This study focuses on Kibera Sub-County to examine the dominant waste streams and assess their contribution to air quality degradation, providing empirical evidence to inform policy formulation, urban planning, and community-based environmental management strategies aimed at enhancing environmental health and sustainability in informal settlements.

Conceptual Framework
Independent variable: Types and sources of waste (domestic, commercial, industrial). Dependent variable: Air quality.



II. Material And Methods

This cross-sectional comparative study was carried out in Kibera Sub-County, Nairobi City County, Kenya, from January 2025 to June 2025. The study population comprised households, waste workers, and key informants involved in waste generation and management within the five wards of Kibera Sub-County. A total of 384 respondents (both male and female) aged ≥18 years were included in this study.

Study Design: Cross-sectional descriptive and analytical observational study.

Study Location: This was a community-based study conducted in Kibera Sub-County, Nairobi City County, Kenya, covering the wards of Sarang'ombe, Woodley/Kenyatta Golf Course, Makina, Laini Saba, and Lindi.

Study Duration: January 2025 to June 2025.

Sample size: 384 respondents.

Sample size calculation: The sample size was estimated using a single population proportion formula. The target population from which the sample was drawn was 185,777 residents of Kibera Sub-County. A confidence level of 95% and a margin of error of 5% were assumed. The minimum required sample size was calculated as 384 households, which were proportionately distributed across the five wards.

Subjects & selection method: The study population was drawn from households within Kibera Sub-County that were actively involved in daily waste generation and disposal. Households were selected using stratified random sampling across the five wards, followed by systematic sampling within each ward. The questionnaire was administered to household heads or adult members responsible for waste handling. Key informants, including waste workers, community-based organization representatives, and local administrators, were purposively selected due to their direct involvement in waste management activities.

Inclusion criteria:
1. Households located within Kibera Sub-County;
2. Either sex;
3. Respondents aged ≥18 years;
4. Households engaged in daily waste generation and disposal activities;
5. Willingness to provide informed consent.

Exclusion criteria:
1. Respondents aged below 18 years;
2. Households unoccupied during the study period;
3. Individuals unwilling to participate in the study.

Procedure methodology

After informed consent was obtained, a well-designed questionnaire was used to collect data from the recruited respondents. The questionnaire included socio-demographic characteristics such as age, gender, education level, household size, duration of residence in Kibera, and main economic activity, as well as waste-related practices including types of waste generated, sources of waste, waste segregation practices, frequency of waste collection, waste storage methods, waste accumulation near homes, and occurrence of open burning. Information on waste handling practices was obtained from household responses, while observation checklists were used to document visible waste piles, dumping sites, and evidence of burning within the residential areas. Key informant interviews were conducted to collect additional information on waste management operations, institutional arrangements, and enforcement of waste regulations.

Air quality data were obtained from environmental monitoring sensors installed by Nairobi City County and the National Environment Management Authority. Measurements focused on particulate matter ($PM_{2.5}$), carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2). Pollutant concentrations were recorded at selected waste dumping and burning sites before the occurrence of open burning and immediately after burning activities. To assess variation with distance, measurements were taken at approximately 10 m, 20 m, and 40 m from the burning points. Sensor readings were retrieved from the air-quality monitoring database and verified for consistency.

Waste characterization was conducted by categorizing observed waste into organic and inorganic components, including food waste, plastics, paper, metal, rubber, and mixed waste. Information on the sources of waste (domestic, commercial, and industrial) was obtained from household responses and confirmed through field observations. All data collection procedures were conducted using standardized methods throughout the study period to ensure uniformity and reliability.

The major sources of waste identified in the study area were as follows:

Domestic waste generated from households; Commercial waste from markets, food stalls, and small businesses; and Industrial waste from informal garages and workshops.

Particulate Matter Sensor AIRQO Sensor

Figure 3.1: Particulate Matter Sensor

Figure 3.2: AIRQO Sensor

Statistical analysis

Data were analyzed using SPSS version 25 (IBM Corp., Armonk, NY). Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize socio-demographic characteristics, types and sources of waste, waste management practices, and air quality indicators. Pearson's correlation analysis was performed to determine the relationship between waste-related variables and air quality. Multiple regression analysis was conducted to assess the effect of types and sources of waste, waste management practices, and waste accumulation on air quality. Differences in pollutant concentrations before and after waste burning were analyzed using paired comparisons. A p-value of less than 0.05 was considered statistically significant.

III. Result

Response Rate

To collect data, 384 questionaries were distributed among the five words of Kibera sub-county. Of these, 370 were correctly filled and returned, providing a high response rate of 96.4%.

Table 4.1: Response Rate

Response Category	Frequency	Percentage
Returned and complete	370	96.4%
Not returned/incomplete	14	3.6%
Total	**384**	**100.0%**
Source: Research Data (2025)		

A response rate of 96.4% surpasses the minimum acceptable threshold of 70% for survey research (Mugenda & Mugenda, 2003), and thus, the data is deemed highly reliable and representative for analysis and drawing valid conclusions.

Demographic Characteristics of the Respondents

Understanding demographic characteristics helps contextualize the findings by highlighting the socio-economic and cultural dynamics of the study population, which influence waste disposal behaviors and exposure to air pollution.

Gender of the Respondents

The study sought to establish the gender composition of the respondents to determine how waste management practices and air quality perceptions may vary by gender. The study revealed the following results (table 4.2)

Table 4.2: Gender Distribution

Gender	Frequency	Percentage
Male	216	58.4%
Female	154	41.6%
Total	**370**	**100.0%**

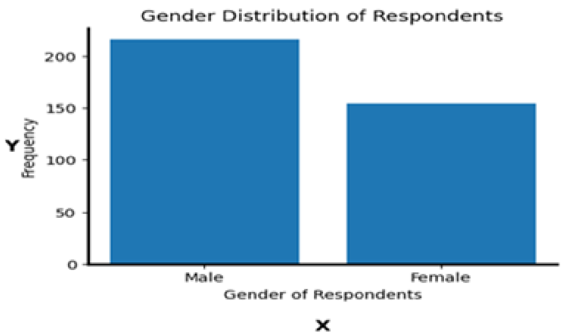


Figure 4.1: Graph showing distribution of respondents by gender
Source: Research Data (2025)

The study revealed that males constituted the majority of the respondents at 58.4%, while females made up 41.6% (Table 4.1 and Fig. 4.1). This shows most of the households in the study area are headed by males often participate more in decision-making, including household-level waste management. However, the considerable female representation enhances inclusivity and gives insight into domestic waste management practices, which are often driven by women for they are the ones who are mostly involved in household chores which generate higher percentage of waste.

Age of the Respondents

Table 4.3: Age Distribution

Age Group	Frequency	Percentage
Below 20 years	18	4.9%
21–35 years	210	56.8%
36–50 years	104	28.1%
Above 50 years	38	10.2%
Total	**370**	**100.0%**
Source: Research Data (2025)		

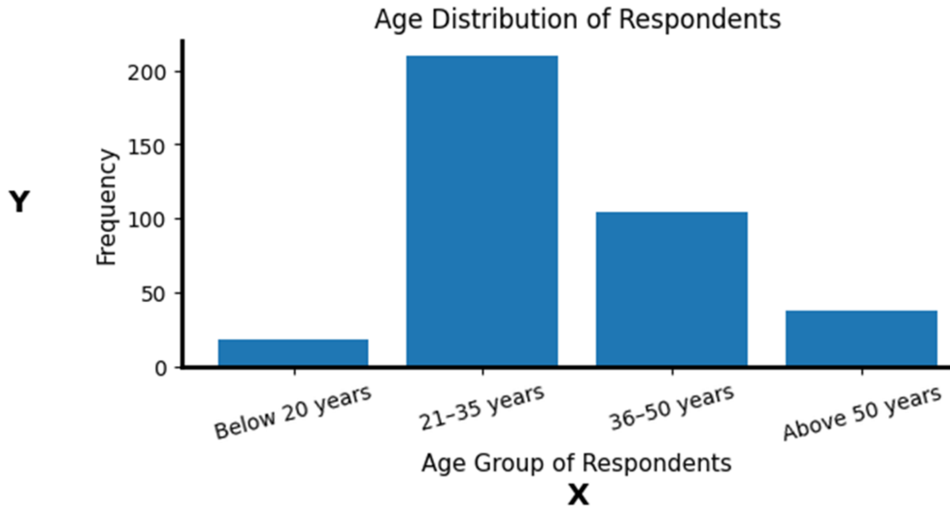


Figure 4.2: A graph showing distribution of the respondents by age

The majority of respondents (56.8%) were aged between 21–35 years, indicating a predominantly youthful population. This group represents the most active demographic in informal urban economies and waste handling. Their engagement in waste generation, disposal, and even recycling is critical to understanding waste-air quality dynamics. Older participants (above 50) contributed 10.2%, providing long-term perspective on changes in air quality and waste handling over time.

Duration of Stay in Kibera

This question was intended to evaluate whether respondents had lived long enough in Kibera to meaningfully assess waste management and air quality trends. The study showed that majority of the respondents had stayed in Kibera for more than 5 years as shown in table 4.4

Table 4.4: Duration of Residence

Duration of Stay	Frequency	Percentage
Less than 1 year	25	6.8%
1–5 years	78	21.1%
6–10 years	110	29.7%
Over 10 years	157	42.4%
Total	**370**	**100.0%**
Source: Research Data (2025)		

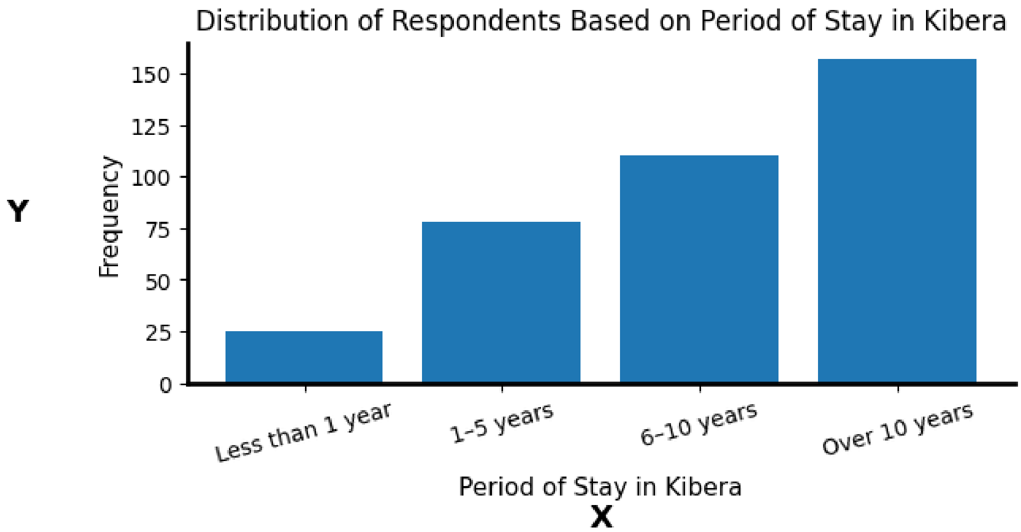


Figure 4.3: A graph showing distribution of respondents based on period stayed in Kibera

Over 42% of the respondents had lived in Kibera for more than 10 years, implying that they have long-term experiential knowledge of waste management practices and changes in air quality. This enhances the credibility of the data collected since long-term residents are more likely to have witnessed patterns of waste accumulation, burning practices, and health implications of poor air quality.

Types and Sources of Waste

This section presents and analyses data on the main types and sources of waste generated in Kibera, given their direct influence on waste accumulation and air quality. Identifying these waste streams is essential for understanding patterns of disposal behavior such as dumping and open burning.

Table 4.5: Types and Sources of Waste

Parameter	SA F (%)	A F (%)	N F (%)	D F (%)	SD F (%)	Mean score	S.D
Most waste in Kibera is domestic (food, plastic, paper)	129 (34.9%)	158 (42.7%)	37 (10.0%)	22 (5.9%)	24 (6.5%)	3.94	1.12
Industrial waste from garages is common in my area	84 (22.7%)	135 (36.5%)	79 (21.4%)	41 (11.1%)	31 (8.4%)	3.54	1.10
Waste from commercial activities is a major issue	95 (25.7%)	167 (45.1%)	69 (18.6%)	24 (6.5%)	15 (4.1%)	3.82	0.97
Waste is dumped near homes and public paths	138 (37.3%)	173 (46.8%)	34 (9.2%)	16 (4.3%)	9 (2.4%)	4.12	0.88

Source: Research Data (2025)

The results indicate that domestic sources constitute the largest contributor to waste generation in Kibera, with a mean score of 3.94 and a standard deviation of 1.12. A cumulative 77.6 percent of respondents agreed or strongly agreed that most waste generated in the settlement originates from households. The main types of waste generated from domestic sources include food leftovers, vegetable peelings, plastic packaging materials, paper waste, and small amounts of textile waste. These waste types arise from routine household activities such as food preparation, consumption, and disposal of packaging materials. High population density and frequent daily household activities contribute to the continuous generation of these waste materials, leading to rapid accumulation when collection services are irregular.

These findings are consistent with earlier studies which have shown that household waste forms the largest proportion of waste in informal settlements. The dominance of domestic waste reflects limited waste segregation at the household level, where organic and non-organic waste are disposed of together. Such practices encourage waste accumulation and increase the likelihood of open burning, which directly contributes to poor air quality in Kibera.

Industrial waste from small-scale garages was also identified as a notable source of waste, with a mean score of 3.54 and a standard deviation of 1.10. Slightly over half of the respondents indicated that waste from garages is common in their area. The main types of waste generated from these sources include used engine oil, scrap metal, worn-out vehicle parts, rubber materials such as tyres, and oil-contaminated cleaning materials. Although industrial waste is less prevalent than domestic waste, its hazardous nature increases environmental and health risks when it is disposed of together with household waste. The presence of such waste within residential areas increases the potential for soil contamination and the release of harmful emissions when waste is burned. These findings highlight the need for improved handling of industrial waste from informal garages to prevent its mixing with domestic waste and subsequent contribution to air pollution.

Waste from commercial activities was also identified as a major source of waste in Kibera, recording a mean score of 3.82 and a standard deviation of 0.97. Respondents indicated that markets, food stalls, kiosks, and small shops generate significant quantities of waste. The main types of waste produced from commercial sources include food residues, vegetable waste, plastic bags, cardboard boxes, and disposable food containers. These waste materials accumulate rapidly in market areas due to high levels of daily commercial activity and limited waste collection. The concentration of commercial waste in busy trading zones increases the likelihood of dumping in nearby open spaces and occasional burning when waste is not collected in time. Such practices contribute to the release of pollutants into the air, thereby worsening air quality conditions in the surrounding residential areas.

The results further show that waste is frequently dumped near homes and along public paths, with this statement recording the highest mean score of 4.12 and a standard deviation of 0.88. This indicates that waste from domestic, commercial, and industrial sources is often disposed of close to residential areas. The types of waste commonly dumped in these locations include food waste, plastics, paper materials, scrap metal, and rubber waste. Disposal of mixed waste near homes increases human exposure to pollutants and raises the likelihood of open burning, which negatively affects air quality. The findings demonstrate that waste types generated from different sources are closely linked to disposal practices and air quality conditions in Kibera. The mixing of waste from households, commercial activities, and garages, combined with disposal near residential areas, contributes significantly to waste accumulation and air pollution within the settlement.

Air Quality Measurements

To assess how waste handling practices, influence pollution levels in Kibera, air quality measurements were taken for PM, carbon monoxide (CO), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2). Readings were recorded at different distances (10 m, 20 m, and 40 m) from active burning points to determine how pollutant concentrations change with increasing distance from the source. These results were compared against the World Health Organization (WHO) air quality guidelines to establish whether the measured values exceeded recommended limits. Table 4.9 presents the observed pollutant levels.

Table 4.9: Air Quality Results in Kibera

Pollutant	WHO Standard	10 m	20 m	40 m	Observed Range
$PM_{2.5}$ (µg/m³)	15 µg/m³ (24-hr)	150	80	10	10 – 150
CO (ppm)	10 mg/m³ (8-hr)	20	10	0	0 – 20
SO_2 (ppm)	20 µg/m³ (24-hr)	10	0	0	0 – 10

Source: Field Sensor Data (2025)

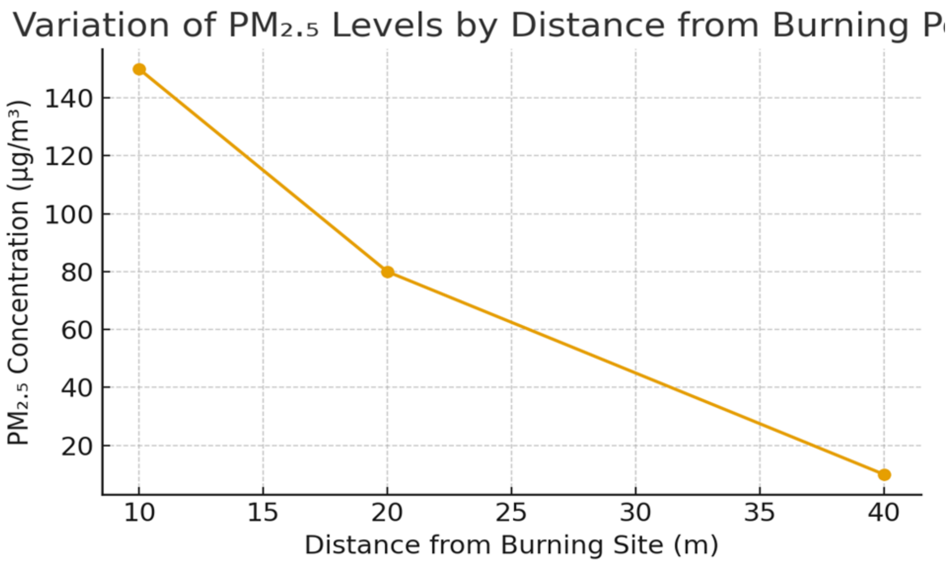


Figure 4.4: A graph showing average of PM 2.5 by distance from burning site per day in Kibera

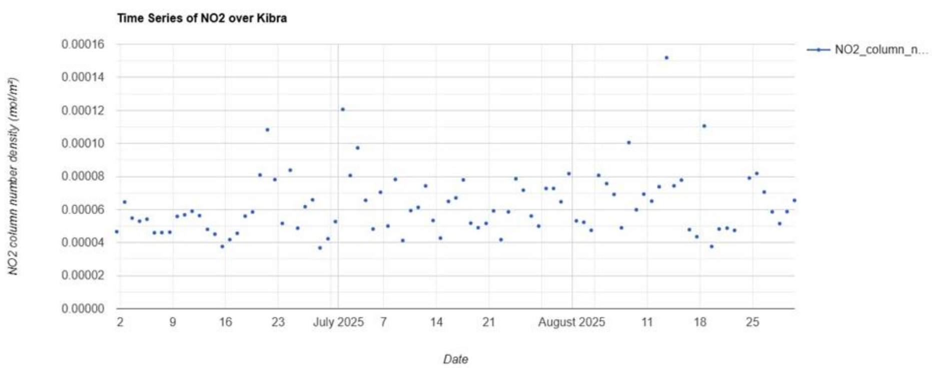


Figure 4.5: Time series of NO2 over Kibera

The air quality measurements presented in Table 4.9 provide empirical confirmation that waste accumulation and open burning are significant contributors to air pollution in Kibera. The measured range of $PM_{2.5}$ concentrations, which varied from 10 µg/m³ to 150 µg/m³, substantially exceeds the World Health Organization 24-hour guideline value of 15 µg/m³, particularly at distances of 10 metres and 20 metres from burning points where concentrations reached 150 µg/m³ and 80 µg/m³ respectively. These elevated levels indicate a serious air quality concern within the settlement. The observed variation in $PM_{2.5}$ concentrations can be explained by several factors, including proximity to open burning sites, the volume of accumulated waste, and the composition of waste materials such as organic matter and plastics, which generate fine particulate emissions when burned. In addition, the dense settlement structure limits dispersion of pollutants, allowing particulate matter to remain concentrated near ground level.

Similar findings were reported by Mukherjee, Singh, and Patel (2021), who documented $PM_{2.5}$ concentrations in informal settlements exceeding recommended limits during solid waste burning. Vilcins et al. (2024) likewise observed elevated particulate matter levels in urban areas characterised by waste accumulation and frequent burning. The contribution of the present study lies in providing direct, location-specific measurements of $PM_{2.5}$ at varying distances from waste burning points in Kibera, thereby demonstrating how waste accumulation and open burning translate into hazardous particulate concentrations within residential spaces. This evidence reinforces existing literature by showing, using local empirical data, that particulate matter is the most critical air pollutant associated with poor waste management practices in low-income urban environments. The Waste Management Theory explains this outcome by emphasising that the absence of structured waste collection and treatment systems results in secondary pollution through uncontrolled burning and decomposition of waste.

Carbon monoxide (CO) levels ranged from 0 to 20 ppm across the three distances measured, showing clear spikes at 10 m (20 ppm) and 20 m (10 ppm) before dropping to zero at 40 m. These readings align with the observations of Gouveia, Mendes, and Costa (2023), who documented that densely populated informal settlements experience high CO concentrations due to the combined effects of domestic combustion and inefficient waste disposal. The WHO (2023) has also classified CO as a priority pollutant because of its capacity to reduce oxygen delivery in human blood, posing serious health risks during prolonged exposure. The elevated CO levels in Kibera thus mirror the household energy and waste-burning behaviors described by Njeru and Mwangi (2021), which are largely driven by limited access to clean energy and poor waste infrastructure.

Sulphur dioxide (SO_2) levels ranged from 0 to 10 ppm, with elevated values recorded at 10 m during burning events and negligible readings at 20 m and 40 m. Raphela, Manqele, and Erasmus (2024) similarly reported that open combustion of non-biodegradable materials, particularly plastics, releases significant quantities of SO_2 and other acidic gases, leading to localized air pollution. The results further confirm the findings of Ahmed and Khan (2020), who associated sporadic sulphur dioxide emissions in urban centers with informal waste incineration. The presence of SO_2, even in low concentrations, is a strong indicator of incomplete combustion processes common in unregulated waste disposal areas.

Nitrogen dioxide (NO_2) concentrations in Kibera generally ranged between 0.00004 and 0.00008 mol/m², with daily fluctuations observed but no discernible long-term trend. This pattern suggests that pollution is driven more by short-term recurring events than by seasonal variation. Comparable findings were reported by Thompson, Lewis, and Carter (2021), who noted that motor vehicle emissions and open burning significantly elevate NO_2 levels in high-density neighborhoods, although fluctuations may remain low during periods of reduced combustion activity. While the concentrations recorded in Kibera did not exceed the World Health Organization's short-term exposure limits, the cumulative effect of prolonged exposure particularly when combined with other pollutants such as $PM_{2.5}$ and carbon monoxide amplifies health risks. This aligns with Mungai and Mutiso (2019), who observed that communities exposed to multiple pollutants from unmanaged waste suffer higher incidences of respiratory ailments, underscoring the importance of integrated air quality monitoring and mitigation strategies.

The air quality data confirm a close relationship between waste management practices and pollutant concentration in Kibera. Periods of open burning and waste disturbance coincided with elevated readings of $PM_{2.5}$, CO, and SO_2, validating the residents' perceptions reported earlier. These findings are consistent with the global and regional literature on waste-related air pollution and demonstrate the cumulative environmental burden of ineffective waste handling. The evidence underscores the urgent need for Nairobi City County and relevant environmental agencies to enforce waste management regulations, enhance public education on waste burning, and promote cleaner energy alternatives to safeguard air quality and public health in informal settlements.

Inferential Statistical Analysis

To determine the strength and direction of the relationship between waste management practices and air quality, regression analysis and Pearson's correlation were performed using SPSS Version 25.

Model Summary

Model summary was done to determine how well the independent variables waste types, waste management practices, and waste accumulation collectively explain variations in air quality in Kibera. It shows the overall strength of the relationship and the proportion of variance in air quality accounted for by the predictors before further tests are conducted.

Table 4.10: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.728	0.530	0.521	0.337

The R Square value of 0.530 indicates that 53.0 percent of the variance in air quality can be explained by the three predictors: types and sources of waste, waste management practices, and waste accumulation. This finding is consistent with the study by Ahmed and Khan (2020), who reported that waste-related variables significantly predict air quality variations in urban areas. Similarly, Gouveia, Mendes, and Costa (2023) found that waste generation, disposal practices, and accumulation patterns collectively accounted for over half of the observed fluctuations in particulate matter concentrations in low-income settlements. The result also aligns with the findings of Mlambo and Ncube (2020), who established that inefficient waste collection and uncontrolled dumping were strong determinants of deteriorating air quality in Johannesburg's informal settlements. Moreover, the proportion of unexplained variance (47.0 percent) corresponds with observations by Vilcins et al. (2024), who noted that additional environmental factors such as meteorological conditions, traffic density, and proximity to industrial sources also influence air quality beyond waste management-related predictors.

ANOVA

Analysis of Variance was conducted to determine whether the combined effect of the independent variables waste types, waste management practices, and waste accumulation significantly explains variations in air quality in Kibera. ANOVA tests whether the predictors, when entered together in the regression model, contribute more explanatory power than would be expected by chance. It assesses whether differences in air quality can be statistically attributed to the variations in waste-related factors measured in the study. The results of the ANOVA test are summarized in Table 4.11.

Table 4.11: ANOVA Summary

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	61.223	3	20.408	49.521	.000
Residual	54.801	366	0.150		
Total	**116.024**	369			
Dependent Variable: Air Quality					
Predictors: Waste Type, Waste Practice, Accumulation					

The significance value (p = .000) is less than the 0.05 threshold, indicating that the model is statistically significant. Therefore, waste types, practices, and accumulation are significant predictors of air quality in Kibera. According to Research (2018), a p-value below 0.05 provides sufficient evidence to reject the null hypothesis and confirms that the relationship among variables is unlikely to be due to random variation. Similarly, Hair, Black, Babin, and Anderson (2019) note that significance levels below this threshold reflect acceptable reliability and validity in explaining relationships within environmental and social science research models.

Regression Coefficients

Regression coefficients analysis was done to determine the specific contribution of each independent variable types and sources of waste, waste management practices, and waste accumulation to changes in air quality. This test shows the direction and strength of influence for each predictor while controlling for the others, allowing the study to identify which waste-related factors have the greatest impact on air pollution in Kibera.

Table 4.12: Coefficients

Variable	B	Std. Error	Beta	t	Sig.
Constant	0.317	0.095		3.337	.001
Types and Sources of Waste	0.238	0.052	.284	4.577	.000

The interpretation of the statistical findings reveals that all the independent variables examined in the study have a statistically significant effect on the deterioration of air quality within informal settlements. This means that each of the selected variables namely poor waste management practices, waste accumulation, and the type or source of waste contributes in a measurable and impactful way to the level of pollution in the air. Similar observations were made by Njeru and Mwangi (2021), who found that waste handling inefficiencies and accumulation significantly reduce air quality in Nairobi's informal settlements. Their study established that poorly managed waste systems in densely populated areas create a continuous cycle of pollution through burning and unregulated disposal.

The results indicate that a unit increase in poor waste management practices is associated with a 0.407-unit decrease in air quality. A decrease in air quality implies an increase in pollution levels. The strength of this relationship suggests that improper handling, collection, and disposal of waste have a pronounced effect on the quality of air, particularly in densely populated and poorly serviced informal settlements. These practices may include open burning of waste, lack of proper segregation, and absence of timely collection, all of which release harmful pollutants such as particulate matter, carbon monoxide, and other toxic gases into the atmosphere. This finding is consistent with the results of Mukherjee, Singh, and Patel (2021), who established that irregular waste collection and open burning were key predictors of increased particulate and gaseous pollutants in low-income urban areas.

The accumulation of waste emerges as another significant factor, contributing to a 0.321-unit decline in air quality for every unit increase in the level of uncollected or unprocessed waste. Accumulated waste often becomes a breeding ground for microbial activity and fermentation, producing foul-smelling gases such as methane and hydrogen sulfide. In addition, it may attract informal incineration as a coping mechanism for waste volume control, further worsening air pollution through uncontrolled combustion processes. Similar results were reported by Vilcins et al. (2024), who found that waste buildup in informal neighborhoods leads to increased emissions of fine particulate matter and methane, both of which contribute to poor air quality and health complications.

The type and source of waste contribute an additional 0.238 units to air degradation. This implies that certain categories of waste, especially industrial, medical, or electronic waste, are more hazardous and, when improperly disposed of or left unattended, release more toxic emissions than general household waste. For instance, burning plastic releases dioxins and furans, while decomposing organic waste emits ammonia and volatile organic compounds (VOCs). These findings mirror those of Ahmed and Khan (2020), who demonstrated that industrial and mixed waste streams emit a wider range of toxic pollutants than domestic refuse, aggravating urban air contamination. Hence, the composition and origin of waste are critical in determining the intensity and danger of pollutants released into the air.

These findings reinforce the hypothesis that unmanaged and hazardous waste management practices have a substantial and statistically proven role in worsening air quality in informal settlements. The results not only highlight the environmental impact of ineffective waste handling but also underscore the public health implications for communities exposed to prolonged periods of poor air quality. The outcomes are in line with the conclusions of Mlambo and Ncube (2020), who associated poor waste governance with heightened air pollution and recommended structured policy interventions and community-based waste management models to mitigate environmental degradation. Therefore, policy interventions targeting systematic and sustainable waste management could play a pivotal role in mitigating air pollution and improving overall living conditions in these vulnerable areas.

IV. Conclusion

Summary of Research Findings

The study achieved a response rate of 96.4 percent, with 370 questionnaires completed out of 384 targeted. The respondents were fairly distributed across gender, age, and duration of residence in Kibera. A majority had lived in the settlement for more than ten years, which gave credibility to their views on waste and air quality. On the types and sources of waste, the study found that domestic waste, particularly food remains, plastics, and paper, dominated the waste streams. Commercial waste from trading centers and industrial waste from garages also made significant contributions. The most serious problem reported was waste dumped near homes and public paths, which was rated with a high mean score of 4.12.

Air quality monitoring confirmed these perceptions in which it was found that $PM_{2.5}$ concentrations in Kibera ranged between 10–150 µg/m³ compared to the WHO daily guideline of 15 µg/m³, with spikes observed during burning of the waste which produces thick smoke. Carbon monoxide levels ranged between 0.020–0.035 mol/m², Sulphur dioxide between 0.0000–0.0002 mol/m², and nitrogen dioxide between 0.00004–0.00008 mol/m². The results showed that air quality in Kibera is frequently compromised by waste accumulation and burning which has become a norm in the area. Inferential analysis established that types and sources of waste, waste management practices, and waste accumulation were significant predictors of air quality. The regression model explained 53 percent of the variance, with waste management practices having the greatest effect ($B = 0.407$, $p < .001$), followed by accumulation ($B = 0.321$, $p < .001$), and type/source ($B = 0.238$, $p < .001$).

Conclusion of the Study

The study concludes that the types and sources of waste in Kibera are predominantly domestic, with food remains, plastics, and paper forming the largest share, while garages and commercial activities also contribute. The proximity of these waste piles to homes and public spaces exposes residents to health and environmental risks.

Recommendations of the Study

Based on the findings and conclusions of this study, the following recommendations are proposed to various stakeholders to improve waste management and reduce air quality deterioration in Kibera.

1. Policy makers and government should strengthen waste collection systems, provide adequate infrastructure, and enforce strict by-laws against illegal dumping and burning.

Suggestions for Further Study

This study concentrated on waste accumulation and its influence on air quality in Kibera, but there remain important areas that require further investigation.

i. A study on the contribution of vehicular emissions to air pollution in informal settlements, since traffic congestion was observed to coincide with spikes in pollutant levels.

ii. A study to examine the effect of small-scale industrial and commercial activities, such as garages and workshops, which emerged as secondary contributors to waste and possible pollution sources.

iii. A study on indoor air pollution from household cooking practices, particularly the use of charcoal and biomass fuels, to understand how indoor emissions interact with outdoor waste-related pollution.

References

[1]. Adedara, M. L., Taiwo, R., & Bork, H.-R. (2023). Municipal Solid Waste Collection And Coverage Rates In Sub-Saharan African Countries: A Comprehensive Systematic Review And Meta-Analysis. Waste, 1(2), 389–413.

[2]. Agyeman, J., Osei, R., & Tufuor, A. (2021). Waste Accumulation And Community Exposure In Dense Urban Settlements. Environmental Science And Pollution Research, 28(44), 62371–62383.

[3]. Amegah, A. K. (2021). Improving Urban Air Quality In Sub-Saharan Africa. Science Of The Total Environment, 755, 142–150.

[4]. Amoako, C., & Frimpong, L. (2020). Waste Handling Practices In Rapidly Urbanising African Cities. Cities, 105, 102–114.

[5]. Anokye, P. A., Frimpong, S., & Boadu, G. K. (2024). Open Burning Of Solid Waste And Respiratory Exposure In Low-Income Settlements. Environmental Pollution, 336, 122–134.

[6]. Atieno, V., & Were, F. (2023). Environmental Risks Of Informal Industrial Clusters In East African Cities. Environmental Science & Policy, 145, 12–21.

[7]. Chikowore, T., Musara, J., & Gwavuya, S. (2023). Waste Disposal Behaviours And Environmental Health In Low-Income Settlements. Environmental Science And Policy, 146, 65–74.

[8]. Choudhary, A., Prajapati, S., & Singh, R. (2021). Informal Waste Burning And Air Pollution Exposure In Urban Communities. Environmental Pollution, 285, 117–142.

[9]. Chukwuma, K., Nwoke, O., & Madu, C. (2024). Household Waste Handling And Emissions In Low-Income Urban Areas. Journal Of Environmental Management, 352, 119–135.

[10]. Clean Air Catalyst. (2023). Understanding Nairobi's Air.

[11]. Engineering X & Royal Academy Of Engineering. (2021). The Global Health Challenge Of Open Burning Of Waste: A Landscape Assessment Of Research In Africa.

[12]. Engineering X. (2021). The Overlooked Emissions: Open Burning Of Waste In Africa. Royal Academy Of Engineering.

[13]. European Environment Agency. (2024). Europe's Circular Economy In Facts And Figures. European Environment Agency.

[14]. Health Effects Institute (State Of Global Air). (2024). State Of Global Air 2024 Report.

[15]. JICA. (2020). Project On Sustainable Solid Waste Management In Urban Areas: Final Report. Japan International Cooperation Agency.

[16]. Kariuki, D., Karanja, J., & Muriithi, L. (2023). Urban Waste Stagnation And The Resulting Impacts On Neighbourhood Air Quality. Waste Management, 157, 40–52.

[17]. Kassahun, D., Wondimu, T., & Bekele, A. (2025). Waste Transfer Points And Environmental Health Risks In Informal Settlements. Waste Management & Research, 43(1), 45–58.

[18]. Kenya Law. (2014/2022). Environmental Management And Co-Ordination (Air Quality) Regulations (Legal Notice No. 34 Of 2014; Revised 2022).

[19]. Kenya Law. (2022). Sustainable Waste Management Act, Cap. 387C (Assented July 6, 2022; Commenced July 26, 2022).

[20]. Kitole, B., Msuya, C., & Kimwaga, R. (2024). Solid Waste Handling Practices And Community Exposure In Dense Urban Neighbourhoods. Journal Of Environmental Management, 349, 119–205.

[21]. Lamu Municipality. (2022). Solid Waste Management Status Report. Lamu County Government.

[22]. Lawal, A., & Bako, Y. (2024). Environmental Health Risks From Unmanaged Waste In Informal African Settlements. Environmental Challenges, 15, 100–352.

[23]. Manshur, T., Luiu, C., Avis, W. R., Bukachi, V., Gatari, M., Mulligan, J., … Pope, F. D. (2023). A Citizen Science Approach For Air Quality Monitoring In A Kenyan Informal Development. City And Environment Interactions, 19, 100105.

[24]. Maphanga, P., & Tshibalo, L. (2025). Capacity Gaps In Waste Management Services In African Cities. Sustainable Cities And Society, 97, 105–118.

[25]. Maphosa, B., Moyo, N., & Dube, T. (2022). Community Waste Disposal Practices And Their Influence On Local Air Quality. Heliyon, 8(9), E10412.

[26]. Marson, P., Muchanga, T., & Kweyu, M. (2023). Spatial Clustering Of Waste And Air Quality Concerns In High-Density Neighbourhoods. Sustainable Cities And Society, 89, 104–152.

[27]. Mayors' Dialogue On Waste Management In African Cities. (2022). Progress Report On Open Burning And Dumpsite Emissions In African Cities. African Union Urban Development Division.

[28]. Muchiri, G., Oduor, J., & Mutua, M. (2023). Household Waste Composition And Disposal Behaviour In Informal Settlements. Journal Of Environmental Management, 330, 117–129.

[29]. Mugambi, M., Mwangi, J., & Kamau, S. (2022). Solid Waste Generation And Disposal Practices In Urban Kenya. Waste Management, 150, 12–23.

[30]. Muheirwe, E., Tukamuhabwa, B., & Twinamatsiko, F. (2023). Household Responses To Waste Collection Challenges In Informal Settlements. Waste Management, 156, 41–50.

[31]. Mwangi, P. (2021). Household Waste Handling Practices In Informal Kenyan Settlements. Kenya Journal Of Environmental Research, 12(2), 55–66.
[32]. Mwigaranzuki, M., Msoffe, R., & Kimwaga, R. (2021). Market Waste Management Practices In East African Cities. Waste Management & Research, 39(5), 732–742.
[33]. Nairobi City County Government, & ECI-Africa. (2019). Nairobi Air Quality Action Plan (2019–2023).
[34]. Nakuru County Government. (2021). Waste Management Act No. 8 Of 2021. Nakuru County.
[35]. Ndirangu, E., Waweru, S., & Ngatia, P. (2021). Community Responses To Prolonged Waste Accumulation In Unplanned Settlements. Urban Environmental Studies, 19(2), 112–128.
[36]. Niyobuhungiro, D., & Zapata, M. (2025). Waste Governance And Service Gaps In Rapidly-Growing African Settlements. Urban Studies, 62(3), 411–429.
[37]. Nyakang'o, B., Kinuthia, J., & Karani, P. (2021). Household Waste Disposal Practices And Air Quality In Low-Income Urban Areas. Environmental Challenges, 4, 100–125.
[38]. Obeng-Odoom, F. (2020). Urban Markets, Waste Generation And Environmental Governance In Africa. Urban Studies, 57(12), 2473–2489.
[39]. Oduor, J., Wambugu, G., & Karanja, S. (2021). Management Of Waste Holding Sites In Dense Urban Settlements. Urban Environmental Research, 18(3), 211–224.
[40]. Oguge, O., Et Al. (2024). Fine Particulate Matter Air Pollution And Health Implications For Nairobi, Kenya. Environmental Epidemiology, 8(1), E303.
[41]. Ramadan, A. H., Said, A., & Mady, A. (2022). Emissions From Open Burning Of Household Waste: A Review. Science Of The Total Environment, 806, 150–172.
[42]. Simiyu, V., Nyaga, J., & Muthee, S. (2023). Household Waste Handling And Its Effects On Neighbourhood Air Quality. Environmental Challenges, 11, 100–260.
[43]. Singh, A., Patidar, S., Ojha, N., & Sahu, S. K. (2022). A Review Of Waste Management And Its Impact On Urban Air Quality: Sources, Pathways, And Mitigation. Frontiers In Environmental Science, 10, 978002.
[44]. Ssekandi, T., Mugisha, M., & Nassozi, S. (2022). Waste Density And Environmental Exposure In Informal Settlements Of East Africa. Habitat International, 121, 102–524.
[45]. Tamura, K., Nguyen, T., & Huynh, L. (2021). Air Quality Impacts Of Open Waste Burning In Low-Income Settlements. Atmospheric Environment, 260, 118–136.
[46]. UNEP. (2024). Global Waste Management Outlook 2024. UNEP – UN Environment Programme.
[47]. UN-Habitat. (2020). World Cities Report 2020: The Value Of Sustainable Urbanization. United Nations.
[48]. UNICEF. (2021). Solid Waste Management And Child Health In Informal Settlements. UNICEF Regional Office For Eastern And Southern Africa.
[49]. World Bank. (2022). Solid Waste Management—Overview & Data (What A Waste Updates).
[50]. World Bank. (2022). What A Waste: Municipal Solid Waste Trends In Africa, 2022 Update. World Bank.
[51]. World Health Organization. (2024). Ambient (Outdoor) Air Pollution: Key Facts.
[52]. World Health Organization. (2024). Household Air Pollution And Health: Fact Sheet.
[53]. Yameogo, K., Zongo, F., & Sawadogo, B. (2022). Urban Household Waste Burning And Particulate Emissions In West African Cities. Environmental Monitoring And Assessment, 194, 687–699.