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Abstract

Purpose: To aim of the study was to analyze the impact of urbanization on air quality in Kenya.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Urbanization in Kenya has significantly increased PM2.5 levels and CO2 emissions, particularly in densely populated cities like Nairobi, driven by rapid population growth, traffic congestion, and industrial activities. Studies show that industrial emissions and reliance on fossil fuels exacerbate air pollution, posing serious public health risks such as respiratory and cardiovascular diseases. Recommendations highlight the need for stricter emission standards, expanded public transport, green spaces, and sustainable urban planning to mitigate the negative effects of urbanization on air quality.

Unique Contribution to Theory, Practice and Policy: Urban ecological theory, sustainable development theory & environmental kuznets curve (EKC) may be used to anchor future studies on the impact of urbanization on air quality in Kenya. To mitigate the impact of urbanization on air quality, it is essential to incorporate green infrastructure in urban planning. Policymakers should focus on strengthening air quality regulations and their enforcement to reduce pollution levels in major African cities.

Keywords: *Urbanization, Air Quality*

INTRODUCTION

The Air Quality Index (AQI) is a measure of air quality, which is closely linked to the concentration of pollutants like PM2.5 (particulate matter with a diameter of less than 2.5 micrometers) and CO2 emissions. High levels of PM2.5 are linked to various health risks, including respiratory diseases and cardiovascular issues, as these particles can penetrate deep into the lungs. CO2 emissions, primarily from transportation and industry, contribute significantly to air pollution and are key drivers of climate change. In developed economies such as the United States, the Environmental Protection Agency (EPA) tracks air quality trends, showing that PM2.5 levels in urban areas have reduced by approximately 40% from 2000 to 2020 (EPA, 2020). For instance, New York City saw a decline in PM2.5 levels from 12 µg/m³ in 2000 to 7 µg/m³ in 2020, reflecting a positive trend toward improved air quality, largely due to stricter emission regulations and cleaner technologies.

In Japan, the situation is similar, as the country has significantly reduced its CO2 emissions in recent years. For example, Japan's PM2.5 levels were recorded at 9 µg/m³ in 2015, compared to 15 µg/m³ in 2005 (WHO, 2018). Furthermore, CO2 emissions in Tokyo have dropped by 23% between 2005 and 2019, a result of energy-efficient policies and the adoption of renewable energy sources (Japan's Ministry of the Environment, 2020). Japan's continuous improvement in air quality is credited to its ambitious environmental policies, such as the Top Runner Program, which encourages the use of energy-efficient appliances. Despite the improvements, occasional spikes in PM2.5 from neighboring countries (e.g., China) still challenge air quality, particularly in winter months, when weather conditions exacerbate pollutant levels (Yamamoto, 2020).

In developing economies like India, PM2.5 levels have been a significant concern, especially in urban areas. Delhi, for example, experiences some of the highest PM2.5 levels globally, with an average annual PM2.5 concentration of around 135 µg/m³ in 2019, which is well above the WHO recommended limit of 10 µg/m³ (CPCB, 2020). The city also sees a sharp increase in CO2 emissions from rapid industrialization and high traffic volumes, contributing to poor air quality. Similarly, Mexico City has struggled with PM2.5 pollution levels, averaging around 20 µg/m³, although this has improved from levels above 40 µg/m³ in the 1990s (UNEP, 2020). These high levels of PM2.5 have been linked to increased health risks, including respiratory infections and cardiovascular diseases. In response, India has taken measures like vehicle emission standards and green energy policies aimed at reducing the air pollution impact.

In Brazil, the air quality situation varies widely between regions, with São Paulo showing significant PM2.5 improvements, reducing from 18 µg/m³ in 2015 to 13 µg/m³ in 2020 (Brazilian Ministry of Health, 2021). However, the country faces challenges in rural areas where deforestation and agricultural practices like burning remain significant contributors to CO2 emissions. Brazil's CO2 emissions are rising, particularly due to increased energy demands and a reliance on fossil fuels. The government has invested in cleaner technologies and renewable energy, but enforcement of air quality regulations is still inconsistent. Brazil's efforts to tackle air pollution in urban areas have seen improvements, but achieving long-term sustainability will require robust policies addressing both industrial emissions and rural activities.

In Sub-Saharan Africa, air quality issues are increasingly concerning due to rapid urbanization, growing vehicle emissions, and limited infrastructure for managing pollution. Lagos, Nigeria,

experiences PM2.5 levels of approximately 70 µg/m³, far exceeding the WHO guideline (Akinyemi, 2020). The primary sources of air pollution in Lagos include the high number of old vehicles, industrial activities, and waste burning. In South Africa, the situation is somewhat similar, with Johannesburg recording PM2.5 levels of 25 µg/m³ (South African Department of Environmental Affairs, 2020). While the country has implemented air quality monitoring systems and cleaner technologies, the increasing CO2 emissions from coal power plants continue to contribute to poor air quality. Sub-Saharan Africa's challenge remains in balancing economic growth with sustainable environmental practices.

In Kenya, Nairobi faces rising PM2.5 levels, with an average of 45 µg/m³ (Kenya Meteorological Department, 2020). This is mainly attributed to the increasing number of vehicles and burning of biomass in both urban and rural settings. However, Kenya's government has launched initiatives such as promoting electric vehicles and expanding the use of clean cooking technologies to reduce CO2 emissions and improve urban air quality. These initiatives are in line with global climate action frameworks, but enforcement of regulations remains inconsistent, especially in informal sectors. Despite these challenges, sub-Saharan countries are beginning to recognize the need for more comprehensive environmental policies to tackle PM2.5 pollution and CO2 emissions effectively.

Problem Statement

Urbanization in Africa has rapidly accelerated over the past few decades, leading to significant changes in the environmental landscape of major cities. As urban populations increase, so does the demand for energy, transportation, and industrial activities, which are key contributors to deteriorating air quality. This rise in urbanization has been linked to an increase in PM2.5 levels and CO2 emissions, both of which have severe health and environmental consequences (Kebede, 2020). Major African cities like Lagos, Nairobi, and Cairo are experiencing growing concerns regarding air pollution, primarily driven by a surge in vehicular emissions, industrial activities, and deforestation for urban development (Akinyemi, 2021). Despite the increasing recognition of air quality issues, limited research exists on how different levels of urbanization specifically affect the concentration of pollutants in African cities. This study aims to explore the relationship between urbanization, air pollution, and the health risks faced by residents, with a focus on understanding how urban planning, industrialization, and infrastructure development contribute to the degradation of air quality in Africa's most populous cities.

Theoretical Review

Urban Ecological Theory

The urban ecological theory, originated by Robert Park in the early 20th century, emphasizes the relationship between urban environments and human behavior. It posits that cities function as ecosystems where various social, economic, and environmental factors interact, often leading to ecological imbalances. This theory is relevant to the topic of urbanization and air quality as it can explain how rapid urban growth, with increased industrialization and vehicular emissions, disrupts the natural balance and exacerbates air pollution in urban settings. The theory highlights the need for sustainable urban planning to mitigate such impacts (Liao & Liu ,2019).

Sustainable Development Theory

The sustainable development theory, promoted by Gro Harlem Brundtland in 1987, advocates for development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This theory is highly relevant to the topic, as it connects urbanization with environmental sustainability, urging cities to balance growth with environmental protection. The theory is pertinent in understanding how urbanization in African cities leads to increased pollution levels and how sustainable urban planning can address air quality issues. Li, Wang & Li (2020)

Environmental Kuznets Curve (EKC)

The environmental kuznets curve (EKC), introduced by Simon Kuznets in the 1950s, posits that as a country's economy grows, environmental degradation increases, but only up to a point. After reaching a certain level of economic development, environmental quality improves due to increased awareness and better regulations. This theory is relevant to understanding the relationship between urbanization, industrialization, and air quality in African cities, suggesting that pollution initially worsens with urban growth but may improve once cities develop sustainable policies (Ozturk & Al-Mulali, 2020).

Empirical Review

Akinyemi (2020) examined the impact of vehicular emissions on air quality in Lagos, Nigeria. Using air quality monitoring data from 2015 to 2019, the study utilized a quantitative approach to assess PM2.5 levels and CO2 emissions across various urban areas. The results indicated a significant rise in PM2.5 levels, particularly in high-traffic zones such as Victoria Island and Lagos Mainland. The study attributed this to an increase in vehicular population and the use of low-quality fuels. The study found that industrial emissions also contributed to worsening air quality. The health risks posed by high PM2.5 levels were highlighted, particularly for respiratory and cardiovascular diseases. Recommendations included enforcing stricter emission regulations for vehicles and promoting cleaner public transport systems. The study also suggested the introduction of electric vehicles and stricter fuel quality standards to curb emissions. Additionally, promoting the use of green technologies in industries and increasing urban greenery were recommended to mitigate the negative effects of urbanization on air quality. Akinyemi highlighted the importance of policy intervention to manage air pollution in rapidly growing cities like Lagos. Despite efforts to control vehicular emissions, the research emphasized that ongoing urbanization could continue to threaten air quality without sustainable urban planning. This study contributes to a growing body of research on urbanization's impact on public health and air quality, particularly in developing countries. The findings underscore the urgent need for proactive environmental management in African cities. The study also stressed that data from continuous air monitoring systems could help in evaluating the effectiveness of air quality policies. Lastly, it urged local governments to prioritize sustainable transport systems and cleaner industrial practices as part of smart city development.

Molina (2018) focused on the effects of urbanization and industrialization on air quality in Mexico City. Their study used air quality monitoring stations to track PM2.5 and CO2 emissions from 2000 to 2017. The study aimed to understand how urban growth and industrial activities influenced

the city's air quality, which had been historically poor due to vehicle emissions and fossil fuel-based power generation. Findings revealed that PM2.5 levels had fluctuated, with a noticeable increase during the winter months due to the combination of increased vehicular emissions and fossil fuel use in the industrial sector. The study also pointed out that while Mexico City had implemented regulations to reduce CO2 emissions, the overall air quality remained below recommended levels, with smog and haze still common in the city. The research recommended enhancing air quality regulations by increasing the number of green zones and introducing more cleaner energy solutions for industries. Public transport was also identified as a key area for improvement, with the study suggesting the expansion of electric buses to reduce reliance on diesel. Furthermore, green urban spaces were promoted as an effective way to absorb pollutants and improve overall air quality. The authors emphasized the role of environmental governance and the need for a more integrated approach to urban and environmental planning. Despite progress, Molina warned that rapid urbanization could lead to further air quality deterioration without more effective mitigation measures. This research was significant in understanding how economic growth in developing urban areas could be balanced with environmental sustainability. As Mexico City is one of the most polluted cities globally, this research contributes to global discourse on how industrial growth and urbanization in emerging economies contribute to persistent air quality challenges.

Kebede (2020) investigated the relationship between urbanization, population density, and air pollution in Addis Ababa, Ethiopia. The study combined air pollution data collected from monitoring stations with interviews from local residents and policymakers. The researchers found that rapid urbanization was directly linked to an increase in PM2.5 and CO2 emissions. The data showed that PM2.5 levels were significantly higher in central urban areas compared to the outskirts, primarily due to industrial emissions and increased vehicle use. The study highlighted that despite Ethiopia's rapid development, poor infrastructure and a reliance on traditional biomass for cooking continued to exacerbate air quality issues. Kebede recommended policy reforms that would encourage the transition to cleaner energy sources and reduce deforestation. They also suggested promoting green building practices and sustainable urban planning to curb the growing air pollution in the city. The authors pointed out that public health in Addis Ababa was at risk, with rising cases of respiratory diseases linked to poor air quality. Additionally, the study recommended that local authorities strengthen air quality monitoring systems and enforce emission standards to mitigate the negative impact of urbanization. Kebede argued that while urbanization was inevitable, managing its environmental impact required robust urban policy interventions that emphasized clean technology adoption.

Adebayo (2019) examined the impact of urbanization on air quality from 2014-2018. They focused on the correlation between traffic congestion, industrial emissions, and PM2.5 levels. The study used both air monitoring data and urban development statistics to measure the effects of increasing population density on air pollution. Results indicated a significant increase in PM2.5 concentrations in areas with high traffic volumes, especially around major roadways. The study also found that industrial emissions from factories along the outskirts of the city contributed to worsening air quality. Adebayo recommended expanding public transport systems, introducing green spaces, and enforcing stricter vehicle emission standards as measures to improve air quality. The study also highlighted the need for alternative energy solutions to reduce industrial emissions,

particularly in informal sectors. It concluded that sustainable urban planning was crucial for balancing urban growth with environmental protection in Nairobi. Their recommendations were aimed at fostering a more sustainable urban environment that could mitigate the effects of growing urbanization on air quality.

Ozturk (2020) explored the effects of economic growth and urbanization on air quality in Sub-Saharan Africa, specifically focusing on Accra and Kigali. Using panel data analysis from 2000-2017, the study examined how urban expansion and increased industrialization led to rising PM2.5 levels and CO2 emissions. Their findings suggested that although both cities had experienced economic growth, urbanization had resulted in increased pollution due to higher industrial and transport emissions. Ozturk also noted that while environmental policies were in place, their enforcement remained weak, and urban expansion often occurred without considering environmental impact. They recommended improving urban infrastructure and encouraging the use of sustainable technologies to mitigate air quality issues. Additionally, the study highlighted the need for government intervention in the form of better urban planning to address the long-term environmental impacts of urban growth.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low-cost advantage as compared to field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

FINDINGS

The results were analyzed into various research gap categories that is conceptual, contextual and methodological gaps

Conceptual Gap: The studies reviewed highlight the relationship between urbanization, industrialization, and air quality but often focus primarily on vehicular emissions and industrial outputs as the central causes of air pollution. While these are key factors, other significant contributors, such as informal sectors, biomass burning, and population mobility, are often underexplored. Additionally, the spatial distribution of air quality within cities and the socioeconomic implications of poor air quality on marginalized communities are not fully addressed. Further research is needed to incorporate these conceptual elements, expanding the scope of urbanization's impact on environmental health in African cities (Akinyemi, 2020; Kebede, 2020).

Contextual Gap: While studies like those by Molina (2018) and Ozturk (2020) focus on air pollution in major cities, there is a lack of contextual understanding of cultural practices and local governance structures in African cities. These factors can influence how cities manage air quality, as seen in Ethiopia and Kenya, where biomass burning and informal fuel use are prevalent (Kebede, 2020; Adebayo, 2019). The research does not fully examine the role of community-based initiatives or the capacity of local governments to enforce air quality regulations in these regions. More research should focus on the local governance context and how cultural behaviors and socioeconomic inequalities exacerbate air quality issues in urban areas.

Geographical Gap: Most of the studies reviewed focus on large urban centers in Africa, such as Lagos, Addis Ababa, and Nairobi, leaving smaller cities and rural-urban transition zones under-explored. Akinyemi (2020) and Kebede (2020) primarily study major metropolitan areas, but suburban and peri-urban areas often experience different pollution dynamics due to factors like low traffic volumes, industrial proximity, and rural-based industries. Further studies are needed to explore air quality in smaller towns and rural areas to understand the geographical variability in urbanization's effects on air quality across different regions in Africa.

CONCLUSION AND RECOMMENDATIONS

Conclusions

Urbanization in major African cities has brought about significant challenges to air quality, with the rapid growth of urban populations and industrialization contributing to increased pollution levels. Studies, such as those by Akinyemi (2020), Molina (2018), and Kebede (2020), reveal that PM2.5 levels and CO2 emissions have risen considerably in urban areas, driven by factors such as vehicular emissions, industrial activities, and poor infrastructure. As cities continue to expand, the resulting environmental degradation poses serious health risks, particularly for vulnerable populations. The need for sustainable urban planning, stricter emission regulations, and the promotion of clean energy solutions has been emphasized in these studies as key measures to mitigate air pollution.

However, significant gaps remain in addressing the geographical differences in pollution dynamics across African cities and the local governance challenges that hinder effective air quality management. Future research should focus on smaller urban areas, peri-urban regions, and informal sectors to comprehensively understand the diverse factors influencing air quality. There is also a need for more context-specific solutions that consider the unique cultural practices, economic structures, and governance capacities of African cities. Ultimately, improving air quality in these cities will require an integrated approach, combining environmental policy reforms, technological innovations, and community engagement to promote healthier, more sustainable urban environments across the continent.

Recommendations

Theory

There is a need to integrate environmental justice into the study of urbanization and air quality in African cities. This theoretical approach examines how air pollution disproportionately affects vulnerable and marginalized communities, including low-income neighborhoods, informal settlements, and peri-urban areas. While traditional urbanization theories often focus on economic growth and industrialization, the environmental justice theory highlights the unequal distribution of environmental harms and benefits. Future research should explore how socioeconomic inequality, informal economies, and cultural practices influence exposure to air pollution and access to environmental resources.

Practice

To mitigate the impact of urbanization on air quality, it is essential to incorporate green infrastructure in urban planning. This includes expanding urban green spaces, increasing urban

tree canopies, and promoting vertical gardens and green roofs. Such initiatives not only absorb pollutants but also reduce the urban heat island effect and improve public health. Evidence from cities like Mexico City and Lagos suggests that integrating nature-based solutions can help absorb PM2.5 and CO2 emissions, enhancing air quality in rapidly urbanizing areas. Urban designers and city planners must prioritize green spaces to counteract the environmental damage caused by industrialization and urban sprawl.

Policy

Policymakers should focus on strengthening air quality regulations and their enforcement to reduce pollution levels in major African cities. This includes setting stricter standards for vehicle emissions, enforcing fuel quality regulations, and promoting clean energy alternatives. Given that most African cities face challenges in implementing existing environmental policies, there is a need for policy coherence and inter-governmental collaboration to ensure compliance across local and national levels. The implementation of smart city technologies, such as air quality monitoring systems, will help policymakers assess and manage air pollution in real-time. Furthermore, integrating air quality concerns into urban development plans and sustainable transport policies is essential to curbing the long-term effects of urbanization on air quality.

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