

# Exploring Spatial Clustering of Industrial Air Pollutants and Its Implications in Jos City, Plateau State, Nigeria

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## ABSTRACT

This study investigates the clustering of industrial air pollutants in Jos Metropolis, focusing on identifying key pollutants, mapping their spatial distribution, and assessing the associated implications. The research employed a mixed-method approach, integrating geospatial analysis, environmental monitoring, and socio-demographic surveys to evaluate air quality and its associated implications. Primary data were collected from 30 strategically selected sampling points across industrial, residential, and commercial zones of the Metropolis. Air quality measurements were conducted using a handheld gas analyzer (Aeroqual Series 500) to monitor concentrations of Total Suspended Particulate (TSP), particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), and heavy metals (Pb, Cd, Hg). Secondary data, including satellite imagery (Landsat 8 OLI/TIRS) for spatial analysis, demographic statistics, and Geographic Information Systems (GIS), were used to map industrial clusters and pollution hotspots, while the Nearest Neighbor Analysis (NNA) quantified spatial distribution patterns. Findings reveal that air pollution in Jos Metropolis is concentrated in industrial and mining zones, with TSP values ranging from 231–600  $\mu\text{m}$ , indicating poor air quality in areas like Rayfield and Dilimi. PM<sub>2.5</sub> and PM<sub>10</sub> levels exceeded WHO and FMEnv standards, posing significant health risks such as respiratory and cardiovascular illnesses, environmental, social, tourism, and economic challenges.

Industrial activities, including mining, metal fabrication, and agro-processing, are major contributors to elevated pollutant levels in the city. In contrast, areas with minimal industrial activity, such as Hill Station Hotel, recorded TSP values of 0–75  $\mu\text{m}$ , reflecting better air quality. It is recommended that agencies such as NESREA should strengthen regulatory enforcement to limit industrial emissions. Other recommendations included the adoption of cleaner production technologies, effective urban planning interventions, and sustained public education.

## KEYWORDS

air pollutants; clustering; air quality; implication; Jos city

## 1 INTRODUCTION

Industries play a crucial role in global economic development by improving citizens' welfare and supplying essential goods (Angwe & Gabche, 1997). According to Imeokparia & Ediagbonya (2014), small and medium enterprises play significant roles in the advancement and development of the economy. It is postulated that the era of the Industrial Revolution introduced the concentration of skills (manpower) and crafts (industries) in the large urban centers, and, in effect, led to the draining of the skilled labour from the former villages and town industries (NGS, 2025). In EU countries, industries provide about 85% of new jobs and employ two-thirds of the workforce (Gherghina, 2020). Tariq et al. (2006) observed that industries possess a pulling force, which attracts particularly commercial and residential land uses around them. Individual firms want to produce a convenient environment for their workers; as such, they will not stop or discourage them from living around the factory. This has instigated growth in industries, which have resulted in the appearance of ill-concerned high-density housing areas adjacent to and intermingled with factories and other features of industrial expansion. Such incidents have occasioned the emergence of low-standard buildings in form of squatter settlements and informal activities around them. Consequently, a gradual physical expansion of the cities ensued (Matovu 2010).

Growing concerns about environmental degradation, climate change, and quality of life have led to a global consensus on the importance of sustainable economic growth. However, industrial activities must balance economic growth with environmental sustainability, as industrialization has contributed to increased population growth, urbanization, and strain on life-supporting ecosystems (Weeks, 1975). African countries have become interested in economic revolution through refurbishing their manufacturing sectors. But the environmental consequence of industrialization is an issue of great concern, with the need to maintain a sustainable environment in line with Sustainable Development Goals (Aquilas et al., 2024). The foregoing views affirm that rapid industrial expansion, coupled with limited land availability, has made environmental sustainability a key consideration in industrial development. The transition to environmentally friendly industries is a vital part of this effort (Angwe & Gabche, 1997).

Air pollution has emerged as one of the most critical environmental challenges confronting urban centers globally. In Europe, industries contribute to 60–70% of industrial pollution (Miller et al., 2011). Enhancing the environmental performance of industries is crucial for achieving sustainable economic development. Industrialization, while fostering economic growth and employment, has been a major source of airborne pollutants, including particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), volatile organic compounds (VOCs), and heavy metals (WHO, 2018). In developing countries, the challenge is more pronounced due to negligent enforcement of environmental regulations, poor urban planning, and insufficient monitoring infrastructure (Ezeh et al., 2018). However, research has predominantly focused on the economic benefits of industries, with limited attention to their spatial distribution and its diverse implications in developing countries (Lall et al., 2008).

It is noted that spatial processes are mechanisms that produce spatial structures of distribution. This implies that spatial patterns of industries result from underlying economic, geographic, and social factors (Weber, 1929; Abler et al., 1972). Similarly, the spatial clustering of air pollutants is a function of multiple factors, including the location of industries, prevailing wind directions, topography, and built environment structures (Uba, 2015; Mukherjee et al., 2021). Understanding these processes provides insight into the forces shaping industrial location and distribution. Therefore, industrial cluster analysis, which is the examination of the spatial organization of industrial activities, has become a necessity (Smith, 1981; Qing, 2012).

Jos City, the capital of Plateau State in North-Central Nigeria, is currently undergoing urban and industrial transformation. The proliferation of small and medium-scale industries, such as mining, metal fabrication, food processing, and printing, is increasingly contributing to local air quality deterioration. Unlike vehicular emissions that are more dispersed, industrial emissions often exhibit spatial clustering—localized concentrations of air pollutants around industrial zones (Zhang et al., 2019). These clusters can have serious health and environmental consequences, especially in densely populated areas.

In Jos, which lies on a plateau with varying elevations and natural wind corridors, pollutant dispersion is highly variable, making spatial analysis essential. Yelwa and Adamu (2014) carried out research and reported that certain industrial areas exhibited higher concentrations of suspended particulates, particularly during dry seasons in Jos city. However, their study lacked spatial modeling, and no clear pollution maps were developed. The current study seeks to bridge this gap by integrating spatial data and air quality monitoring to understand the distribution and concentration of industrial pollutants in Jos. Moreover, there is a scarcity of empirical studies addressing the spatial dimensions of air pollution in the city. This study, therefore, investigates the spatial clustering of industrial air pollutants in Jos City using geospatial analysis techniques. It aims to identify pollution hotspots, evaluate their impact on local air quality, and discuss the implications for social, economic, tourism, urban health, environmental management, and policy formulation.

## 2 MATERIAL AND METHODS

This study was carried out in Jos metropolis, including Jos North and Jos South Local Government Areas. Jos North Local Government Area, with its headquarters situated in the city center of Jos, is located between latitude 9° 55' N and longitude 8° 54' E. It covers a total land area of 291 km<sup>2</sup> and had a population of 437,217 during the 2006 census. Jos South Local Government Area is situated between latitude 9° 46' N and longitude 8° 43' E, with its headquarters in Bukuru town. It has an area of 510 km<sup>2</sup> and a population of 311,392 as of the 2006 census. Jos metropolis serves as the political, economic, industrial, and administrative hub of Plateau State. The metropolis is a fast-growing city in North-central Nigeria. It is about 109 km from Bauchi city, 200 km from Lafiya, 298 km from Makurdi, and 313 km from Abuja, the Federal Capital Territory (FCT).

The study is descriptive in nature and utilizes both quasi-experimental and quantitative data. The primary data included industrial site analysis, impact of industrial activities on air quality, the environment, and the entire society.

The secondary data were records from INEC and NPC, Satellite/Landsat images, World Health Organization (WHO), National Environmental Standards and Regulation Agency (NESREA). Data were collected through reconnaissance, structured questionnaire, guided interview, handheld GPS Garmin Etrex, Handheld Gas Analyzer, and the Internet. The collected data were sorted and analyzed according to the established standards, and further processed from biodata, remote sensing data, ambient human health data, population data, and site characteristics data.

Both stratified random sampling and purposive sampling techniques were used for the data collection. Stratified random sampling was used to divide the study area into strata (wards). From each ward (stratum), the simple random sampling method was applied to select the required sample size of respondents. While purposive sampling was adopted to select industrial areas and affected land uses for measurement. The data sourced from the field survey were analyzed using descriptive statistics, particularly tables. ArcGIS software was used to map and build a geoextent for industries, while environmental quality was tested using Aeroqual.

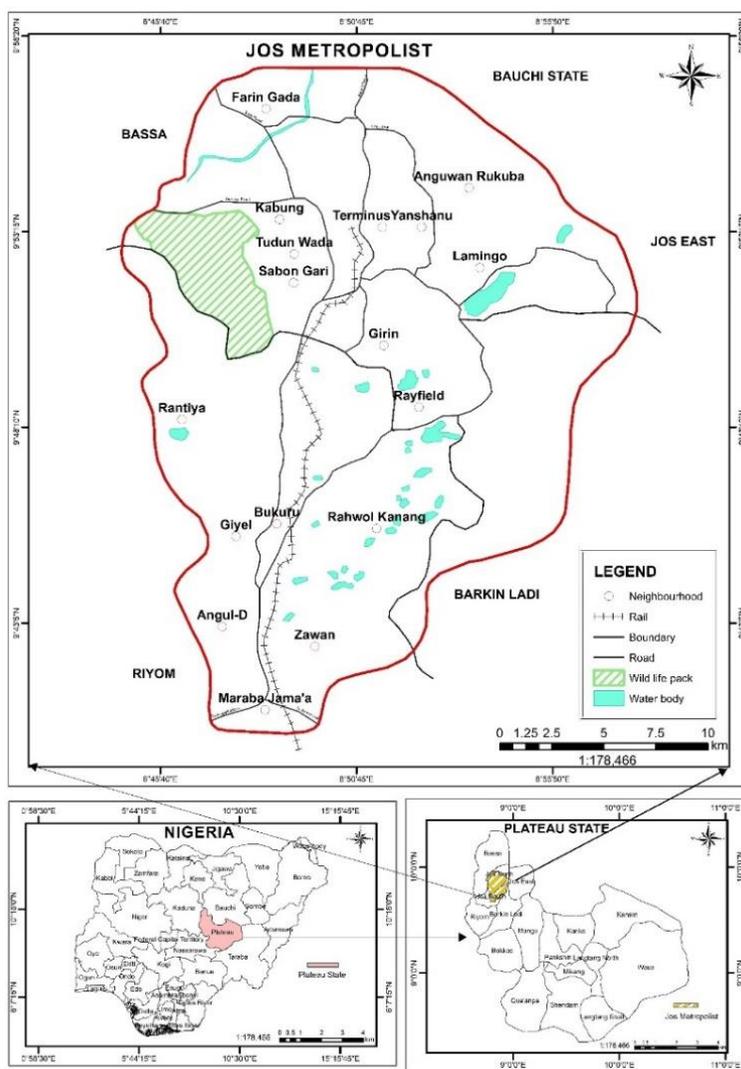


FIGURE 1: The Study Area (Plateau State MHUD, 2023).

### 3 RESULTS AND DISCUSSION

This section presents the results and analyzes the data collected from the field. The result is illustrated in separate sections as follows:

#### 3.1 Spatial Distribution of Industries and Air Pollutants Cluster

The map in Figure 2 provides spatial dispersal of industrial pollutants in Jos city, giving critical insights into how industrial activities are concentrated in specific areas. Nearest Neighbor Analysis was conducted, and it reveals that industries are heavily concentrated in certain districts, such as Dilimi, Bukuru, Dadin Kowa, and Rayfield.

This pattern of industrial dispersal in Jos metropolis is consistent with the theoretical framework of industrial agglomeration, which suggests that industries tend to concentrate in areas where they can benefit from shared infrastructure, reduced transportation costs, and access to raw materials.

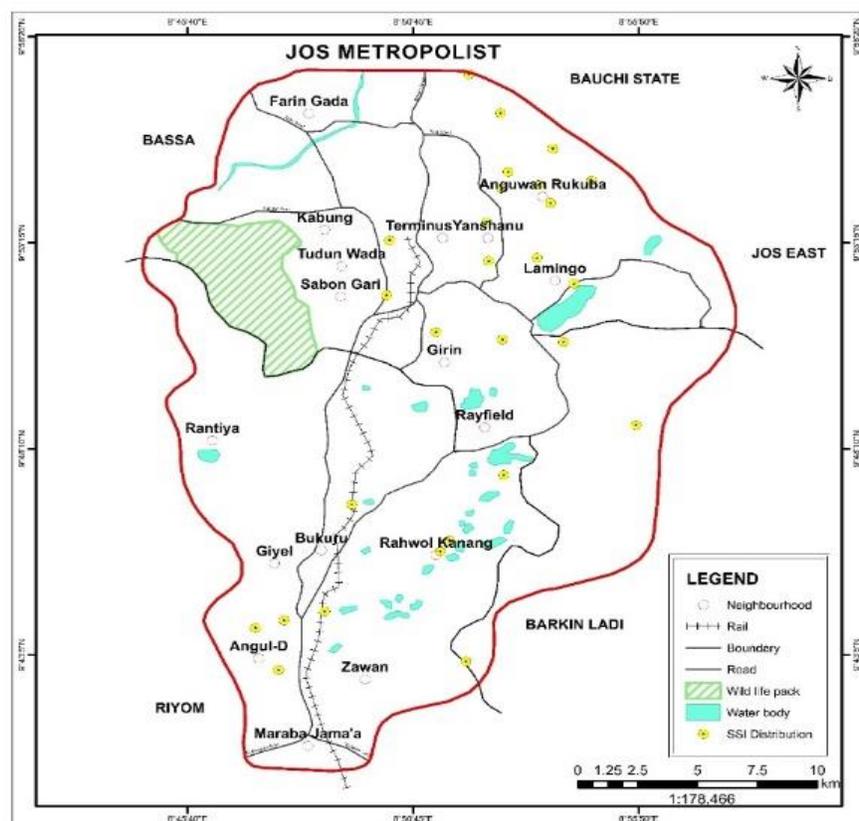


FIGURE 2: Spatial Dispersion of Industries in Jos Metropolis.

### 3.2 Categories of Air Pollutants in Jos Metropolis

Air pollution in Jos Metropolis is a pressing environmental challenge, primarily driven by activities in the prevailing industries, urbanization, and increasing vehicular emissions. The types of air pollutants vary based on the nature of industrial operation, urban infrastructure, and waste management practices. The prevalent key air pollutants in Jos metropolis, their spatial distribution, and intensity were studied and illustrated as follows:

- i. **Particulate Matter (PM):** Fine particles suspended in the air, such as dust, soot, and smoke, are primarily emitted by construction activities, block molding industries, and mining operations. PM is categorized as PM<sub>10</sub>, referring to particles with a diameter of 10 micrometers or smaller. PM<sub>2.5</sub> is fine particles with a diameter of 2.5 micrometers or smaller, which pose significant health risks due to their ability to penetrate deep into the lungs.
- ii. **Volatile Organic Compounds (VOCs):** These pollutants are emitted from chemical processing in industries, paints, solvents, and fuel combustion. VOCs such as benzene and formaldehyde contribute to smog formation and adverse respiratory effects.
- iii. **Carbon Monoxide (CO):** Emitted from vehicular exhaust and incomplete combustion in manufacturing units, CO reduces oxygen delivery in the human bloodstream, causing cardiovascular and neurological effects.
- iv. **Nitrogen Oxides (NOx):** Generated from combustion processes in industries and vehicles, NOx gases, such as nitrogen dioxide (NO<sub>2</sub>), contribute to acid rain and smog, impacting both human health and the environment.
- v. **Sulfur Dioxide (SO<sub>2</sub>):** Emitted from fuel combustion in industrial production units and power generators, SO<sub>2</sub> causes respiratory problems and contributes to the formation of fine particulate matter.
- vi. **Heavy Metals and Toxic Elements:** Pollutants such as lead (Pb), cadmium (Cd), and mercury (Hg) are by-products of mining, welding, and fabrication industries. These metals settle in dust and can have long-term toxic effects on human health.
- vii. **Greenhouse Gases (GHGs):** Industries and vehicular activities emit carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>), contributing to climate change and localized urban heat islands.

### 3.3 Spatial Clustering of Air Pollutants in Jos Metropolis

The finding in Figure 3 provides clear evidence of the range of harmful air pollutants in Jos Metropolis as earlier outlined, including particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO), nitrogen oxides (NO<sub>x</sub>), and heavy metals such as lead and mercury. These pollutants predominantly concentrate in areas with high accumulation of industries like mining, quarry, and construction companies, especially processing and metal workshops. The affected areas in the metropolis include Anguwan Rukuba, Kabaung, Lamingo, Sabon Gari, Terminus, Tudun Wada, Yanshanu, Rayfield, and Dadin Kowa.

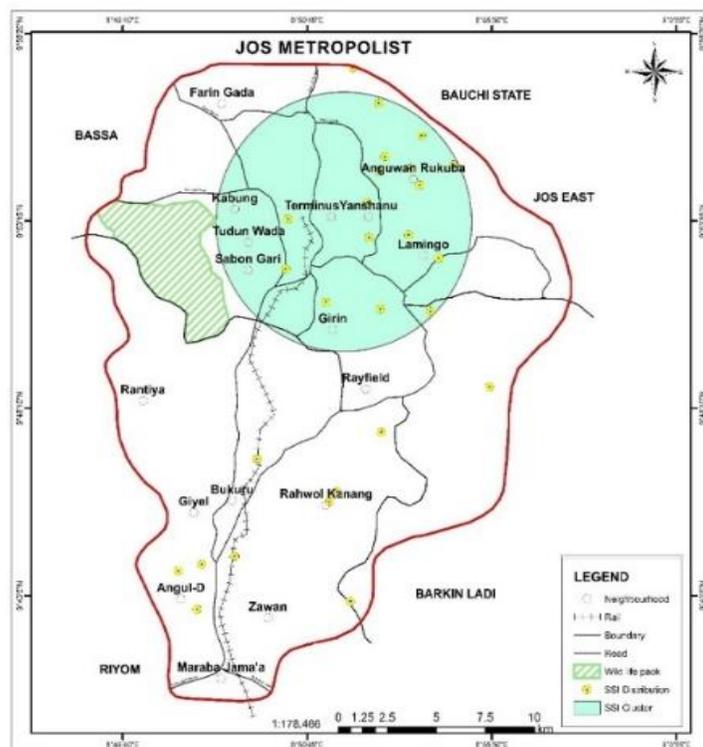


FIGURE 3: Cluster of Air Pollutants in Jos Metropolis.

### 3.4 Spatial and Temporal Extent of Industrial Air Pollutants in Jos Metropolis

The spatial and temporal extent of air pollution in Jos Metropolis was assessed, and the result is presented as follows:

#### 1. Hotspots of Pollution;

- *Industrial Areas:* Clusters in Rayfield, Dilimi, Bukuru, and Gyel exhibit elevated levels of PM, heavy metals, and VOCs due to high industrial activity.
- *Urban Centers:* Terminus Market and Ahmadu Bello Way experience significant vehicular emissions, contributing to elevated CO and NO<sub>x</sub> levels.
- *Mining Sites:* Gyel, Rayfield, Barkin Ladi, and other mining-prone areas report high levels of particulate matter and heavy metals in air and soil.

2. **Temporal Variation:** Air pollutant levels tend to be at their peak during the dry season. This is due to increased dust and a lack of rainfall to wash out pollutants. During high traffic periods and industrial production peak hours, the concentration of CO and NO<sub>x</sub> rises significantly.

3. **Comparative Levels:** Measurements indicate that PM<sub>2.5</sub> and PM<sub>10</sub> levels often exceed the permissible and safety limits set by the World Health Organization (WHO) and the Federal Ministry of Environment (FMEvn). VOCs and heavy metal concentrations are notably higher in proximity to industrial zones and open waste dumps.

Spatial analysis was also conducted it revealing a stark disparity (Figure 4) in air quality between different parts of the city. Industrial areas like Bukuru and Rayfield experience high levels of pollution, while residential areas farther from the industrial clusters, such as Jos North, have significantly lower levels of pollutants. This finding highlights the localized nature of air pollution in Jos, indicating that the impacts of industrial emissions are most severe in areas closest to the sources of pollution. Table 1 summarizes and illustrates the main pollutants, their sources, and the most affected locations within Jos Metropolis.

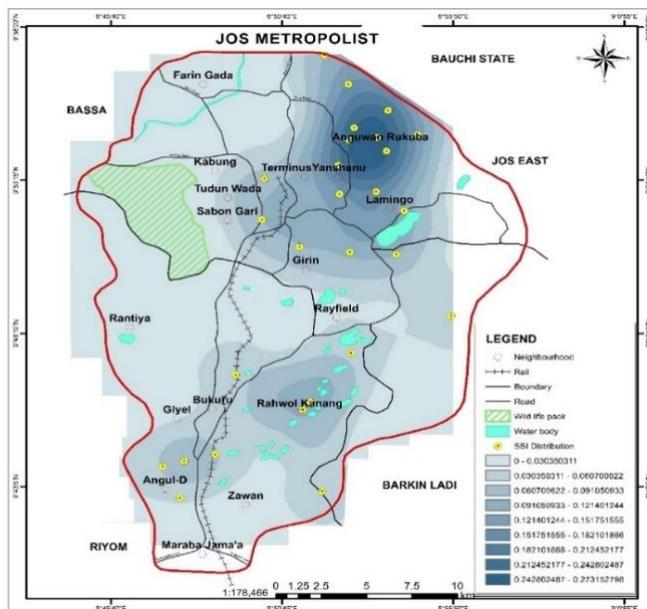


FIGURE 4: Stark Disparity in Air Quality in Jos Metropolis 4.

TABLE 1: Major Industrial Air Pollutants and Affected Areas in Jos City.

| Pollutant                            | Sources   | Affected Areas                         |
|--------------------------------------|---|--|
| PM <sub>2.5</sub> , PM <sub>10</sub> | Quarrying, cereal processing, and vehicular emissions | Jos–Bukuru Road, NASCO vicinity        |
| Sulfur Dioxide (SO <sub>2</sub> )    | Industrial combustion, biomass burning                | Bukuru, Rayfield                       |
| Carbon Monoxide (CO)                 | Fossil fuel combustion, vehicle exhaust               | Ahmadu Bello Way, Terminus Market      |
| Heavy Metals (Pb, Zn, Cd)            | Road dust, industrial emissions                       | Bukuru industrial layout, Dilimi, Gyel |

### 3.5 Air Quality at Various Locations in Jos Metropolis

Table 2 provides an overview of the air quality in various locations of Jos Metropolis, based on Total Suspended Particles (TSP) values. TSP refers to the concentration of airborne particles affecting the overall air quality. The values are categorized into Poor, Moderate, or High quality based on particle size ranges. The table reveals that Equator Mines Limited, Joraai Mining, Kinghill Ventures, Laurium Mining Company Limited and Malco Mines, Mining Technology Company Limited, Moulds Nigeria Limited, Mr. Mike J Gyang and Family, NASCO Group of Companies and Spectrum Minerals Limited Mining Company recorded TSP values between 231-600 μm, and are classified as having poor air quality. This pattern is consistent with other mining sites in Jos Metropolis, where particulate matter from mining processes contributes to poor air quality. Such an outcome buttresses the strong link between industrial and mining activities with elevated air pollution levels. Grand Cereals & Oil Mills Limited recorded two ranges of TSP values – 231-600 μm for poor air quality and 0-75 μm for improved air quality under certain conditions. Despite some lower particle sizes, the overall classification remains poor.

National Veterinary Research Institute (NVRI) and Zarm Poultry and Animal Feed firm recorded TSP values between 76-230 μm, indicating some levels of air pollution, though not as severe as the mining and industrial areas. This moderate air quality at NVRI and Zarm Poultry and Animal Feed indicates a manageable level of air pollution that poses less immediate health risk compared to areas with poor air quality. However, prolonged exposure to particulate matter in this range may still lead to respiratory discomfort, especially for vulnerable groups such as children and the elderly. Environmentally, it could affect nearby vegetation and soil quality, potentially impacting agricultural productivity over time. Regular monitoring and mitigation strategies are recommended to prevent further deterioration.

Hill Station Hotel is the only site classified as having high-quality air, suggesting a very low level of air pollution. The absence of significant industrial or mining activities in this area likely contributes to the cleaner air conditions. This high air quality at Hill Station Hotel suggests a healthier environment for residents and visitors, reducing the risk of respiratory and cardiovascular diseases. It also enhances overall well-being and supports outdoor activities, making it attractive for tourism and residential purposes. Additionally, cleaner air positively impacts local ecosystems, ensuring sustainable biodiversity and better environmental quality for future generations.

**TABLE 2:** Air Quality Classification Based on Total Suspended Particles (TSP) Values in Jos Metropolis.

| Locality                                      | Air Particle Size | Quality          |
|---|-------------------|------------------|
| Equator Mines Limited                         | 230 – 600         | Poor Quality     |
| Grand Cereals & Oil Mills Limited             | 230 – 600         | Poor Quality     |
| Hill Station Hotel                            | 0 – 75            | High Quality     |
| Joraai Mining Nigeria Limited                 | 231 – 600         | Poor Quality     |
| Kinghill Ventures                             | 231 – 600         | Poor Quality     |
| Laurium Mining Company Limited                | 231 – 600         | Poor Quality     |
| Malco Mines                                   | 231 – 600         | Poor Quality     |
| Mining Technology Company Limited             | 231 – 600         | Poor Quality     |
| Moulds Nigeria Limited                        | 231 – 600         | Poor Quality     |
| Mr. Mike J Gyang and Family                   | 231 – 600         | Poor Quality     |
| NESCO Group of Companies                      | 231 – 600         | Poor Quality     |
| National Veterinary Research Institute (NVRI) | 76 – 230          | Moderate Quality |
| Spectrum Minerals Limited                     | 231 – 600         | Poor Quality     |
| Zarm Poultry and Animal Feed                  | 76 – 230          | Moderate Quality |

#### 4.6 The Implications of Industrial Air Pollutants in Jos City

The findings of this study reveal extensive adverse effects on public health, ecological systems, livelihoods, and the tourism potential of Jos Metropolis. Understanding the multiple dimensions of these pollutants is critical to informing public policy and health interventions, as discussed here after.

**Health Effect:** Air pollutants in Jos City have substantial health consequences, mainly due to high concentrations of respirable particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), hydrogen sulfide (H<sub>2</sub>S), and heavy metals comprising lead, cadmium, manganese, and zinc. The concentration of particulate matter in the industrial zones of Jos metropolis exceeds World Health Organization (WHO) and the Federal Ministry of Environment (FMEnv) safety limits (Eneji et al., 2019; Okonkwo & Ezejiyor, 2014). Consequently, chronic exposure to these pollutants has been linked to diverse health risks, especially respiratory illnesses such as asthma, chronic bronchitis, and emphysema; cardiovascular diseases, including hypertension and ischemic heart disease. It has also resulted in neurological impairments, particularly among children exposed to lead, and eye irritation and allergic reactions. The affected areas in the metropolis include communities near Grand Cereals Limited, NASCO Foods, and the Jos–Bukuru industrial corridor.

**Social Impact:** Industrial pollution excessively affects low-income neighborhoods situated adjacent to industrial facilities. The ensuing environmental challenge manifests in higher health burdens and financial stress among vulnerable populations (Pona et al., 2021). Residents of Rayfield, Gyel, Bukuru, and adjacent settlements frequently report increased household expenditures on healthcare due to pollution-induced diseases, reduced productivity and absenteeism from work, community tensions over inadequate compensation, and lack of pollution mitigation measures. Such social impacts contribute to entrenched poverty and reduced quality of life.

**Tourism Repercussion:** Jos City is known for attractions such as Jos Wildlife Park, Shere Hills, and the Museum of Traditional Nigerian Architecture. But persistent industrial air pollution weakens the tourism potential of these sites. Seasonal haze and dust deposition reduce visibility and degrade the natural aesthetic value critical to eco-tourism (Bacos, 2024). Peculiar examples include reduced air clarity at Shere Hills, which diminishes the experience for climbers and photographers, and dust accumulation in Jos Wildlife Park, affecting vegetation and visitor satisfaction. Such environmental degradation leads to a decline in tourist visits and associated economic losses for local businesses.

**Environmental Cost:** Industrial emissions exert harmful effects on air, soil, and water quality. Air quality measurements reveal  $PM_{2.5}$  and  $PM_{10}$  concentrations consistently above WHO safety limits. The environmental impacts of such concentration include soil acidification and contamination with heavy metals, reduced agricultural productivity due to dust deposition on crops, **and** degradation of surface water quality in Dilimi and Farin Gada rivers. The concentration of toxic metals in road dust and farmland poses risks to both ecosystem integrity and food safety.

**Economic Consequences:** Air pollution imposes substantial economic costs on households, businesses, and government institutions. The direct and indirect costs of pollution-related challenges in Jos include declined agricultural output near industrial zones, high healthcare expenditures borne by families and employers, productivity losses due to work absenteeism, and reduced property values in polluted neighborhoods. Jointly, these economic burdens hinder sustainable development and exacerbate inequality (Wang et al, 2025).

Findings of this study provide strong support for the Environmental Kuznets Curve (EKC), which posits that pollution levels tend to rise during the early stages of industrialization, but can decrease as economies grow and environmental regulations become more stringent. In the case of Jos Metropolis, the high levels of pollution observed in industrial clusters suggest that the city is still in the early stages of industrialization, where economic growth is being prioritized over environmental protection. Without adequate regulation and enforcement, the environmental and health consequences of industrialization are likely to worsen, as experienced in other developing countries.

Furthermore, the findings align with the Behavior and Social Drivers (BeSD) Model developed by the World Health Organization (WHO). The BeSD model emphasizes the importance of social behaviours, governmental policies, and public awareness in shaping environmental health outcomes. In Jos Metropolis, the lack of public awareness about the health risks of air pollution, combined with weak governmental regulation, exacerbates the health impact of industrial pollution. The model highlights the need for comprehensive public health campaigns and stronger governmental intervention to mitigate the effects of air pollution.

Additionally, the study contributes to the theoretical understanding of environmental justice, particularly in the context of industrial pollution. It reveals that low-income communities living near industrial clusters bear the burden of the pollution and its associated health risks. This is consistent with the global literature on environmental justice, which shows that marginalized populations are often disproportionately affected by environmental hazards. In Jos Metropolis, the lack of adequate housing and healthcare further aggravates the vulnerability of these communities, underscoring the need for targeted policy interventions to address the health and environmental disparities.

The findings of this study underscore the need for better urban planning and zoning policies to regulate the spatial proliferation of industries. In many parts of Jos, industries are located in close proximity to residential areas, worsening the health risks for residents. Urban planners must prioritize the separation of industrial and residential zones to minimize exposure to harmful pollutants. Furthermore, there is a need for the Jos Metropolitan Development Board to enforce stricter environmental regulations to ensure that industries implement pollution control measures.

## 5 CONCLUSION

This study provides a thorough evaluation of the spatial dispersal of industrial pollutants, air quality, and the consequent environmental, public health, social, tourism, and economic consequences of air pollutants emitted by industries within Jos Metropolis. The findings reveal a pronounced spatial clustering of industrial facilities in densely populated urban areas, resulting in elevated concentrations of pollutants, including particulate matter, volatile organic compounds, and other toxic emissions. These pollutants have been identified as significant contributors to environmental, economic, social, and health challenges, particularly respiratory and cardiovascular diseases, excessively affecting vulnerable populations such as children and the elderly.

The integration of Geographic Information Systems (GIS) and Remote Sensing (RS) technologies proved instrumental in mapping pollution hotspots and analyzing the spatial patterns of industrial activities. Furthermore, the research highlights critical gaps in regulatory enforcement, industry compliance, and public awareness, all of which have exacerbated social, economic, tourism, environmental degradation, and adverse health outcomes.

Addressing these complex challenges requires a multi-faceted strategy, encompassing strengthened policy frameworks, the adoption of cleaner production technologies, effective urban planning interventions, and sustained public education. This study contributes valuable empirical evidence to inform sustainable development strategies and enhance the quality of life for residents of Jos Metropolis.

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